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THE PHYSICS OF THE DIAMOND

BY reason of its remarkable properties, diamond is a substance of extraordinary interest to the physicist interested in the study of solids. It exhibits in a characteristically striking fashion, many phenomena which are scarcely noticeable with other solids in ordinary circumstances. As an instance, we may recall the variation of specific heat with temperature. This was known as an experimental fact in the case of diamond for at least fifty years before it was recognised as a universal property of the solid state; the data for diamond published by Weber in 1875 formed the basis of Einstein's epoch-making paper of 1907 introducing the quantum theory of specific heats. History has a way of repeating itself, and the study of diamond should therefore appeal strongly to the experimenter seeking new avenues of research and to the theorist seeking new and fruitful lines of physical thought concerning the solid state.

For the reasons stated, I have since the year 1930 been deeply interested in physical investigations on the diamond. The difficulty of obtaining the material in a form suitable for exact studies has, however, been a serious obstacle to progress. Indeed, in the early days, I was reduced to the expedient of borrowing diamond rings from wealthy friends who, though willing to oblige, were slightly apprehensive about

the fate of their property! More recently, these difficulties have diminished as the result of the discovery that flat plates of diamond of excellent quality are not very expensive and can be purchased in useful sizes from many jewellers in India. The collection of diamonds got together in this way has enabled studies with this crystal to figure prominently in the Bangalore researches on the solid state. Results of fundamental importance have been reached by spectroscopic investigations on light-scattering, on absorption in the visible and ultra-violet, on fluorescence and phosphorescence, and by X-ray studies on numerous diamonds. It is no exaggeration to say that the experimental facts revealed by these researches have opened up a completely new view of the physics of the crystalline state.

My knowledge of diamonds in their natural condition has improved and my personal collection of material for study has been notably enlarged, following a visit by me to the State of Panna in Central India where diamond-mining and diamond-working have been carried on since ancient times. I carried with me to Panna, a microscope, a strain-viewer, an ultra-violet lamp and a small quartz spectrograph. With the aid of this apparatus and with the kind co-operation of Mr. Balkrishna who is Director of Industries in the State, Mr. Nayar and myself were enabled to examine several hundred diamonds in their natural condition. We were also graciously permitted by His Highness the Maharaja of Panna to examine his famous garland of 52 large diamonds strung together in their natural state as crystals. The 25 uncut diamonds I purchased and brought back to Bangalore form a representative collection chosen for their scientific interest. There is little doubt that their detailed examination will yield a rich harvest of results.

2. The Crystal Forms of Diamond

The reports on the diamond deposits in the Panna State published by E. W. Vredenburg (1906) and by K. P. Sinor (1930) include a good deal of information of interest to the physicist and crystallographer. Sinor has a whole chapter in his book, accompanied by drawing and illustrations, concerning the physical characters of the Panna diamonds. Personal observation, however, is necessary to enable one to appreciate the remarkable beauty of these diamonds in their natural condition. With their exquisitely perfect geometric form and their smooth lustrous surfaces, they look absolutely fresh from Nature's crucibles, though actually taken from sedimentary formations which according to the geologists, are a thousand million years old. The strongly-marked curvature of the crystal faces and smoothly rounded edges of the octahedral forms are a surprising feature of these crystals. It is clear, however, from the symmetry of shape, the smoothness of the faces and the fact that forms more complex than the octahedron are represented by sharp edges that the diamonds as we now see them are exactly in the same state as when they were first formed.

I wish to put forward tentatively a suggestion which seems to me to offer a reasonable interpretation of the facts stated above. If carbon liquefied under suitable

conditions of temperature and pressure when surrounded by molten silicious material, the form of the drops of the liquid diamond would be determined by the interfacial tension and would be spherical, provided the valence bonds between the atoms of carbon in the liquid were oriented completely at random. If, however, some measure of regularity in the orientation of the valence bonds could be assumed, the conditions within the liquid would roughly approximate to those in the solid crystal; in other words, *diamond in the molten state would be a liquid crystal.* The interfacial tension would then vary with direction and the surfaces of minimum energy would not be spherical, but would tend to show some resemblance to the forms exhibited by a cubic crystal. If the shapes assumed by diamond in the liquid crystalline state persisted on solidification or else suffered only minor changes, we would have an explanation of the forms now observed.

3. Accidental Birefringence in Diamond

Mr. Sinor examined many of the Panna diamonds under the polarisation microscope and writes as follows:—"*Very clear crystals in which all the faces were symmetrically developed showed very little or no double refraction. Crystals full of flaws and inclusions and distorted crystals showed the colour bands very well.*" This important finding agreed with the observations made by Mr. Nayar and myself at Panna with numerous diamonds placed between the nicols of a simple strain-viewer. It has since been fully confirmed by careful observations under the polarising microscope made at Bangalore with the 25 Panna diamonds, the disturbing effects produced by their external surfaces being eliminated by immersion of the specimens in a highly refractive liquid.

The absence of birefringence in clear and symmetrically developed diamonds and its presence in defective and distorted diamonds are precisely what we should expect if a liquid crystalline condition of molten carbon preceded the formation of solid diamond. If the fluid material attained complete uniformity as well as mechanical and thermal equilibrium with its surroundings before solidification, a homogeneous crystal would have formed, while if it did not, the resulting solid would exhibit a lack of homogeneity with consequent development of internal stresses and strains manifesting themselves in an observable birefringence. On this view, the birefringence when observed is essentially a macroscopic effect which does not differ in its physical nature from the birefringence artificially produced by the imposition of external stress on a homogeneous crystal. This interpretation is supported by the fact that the restoration of light is most strongly marked in the vicinity of visible flaws and defects and that by cleaving off the defective parts, the rest of the material may be freed from strain, with the result that the birefringence in it disappears. I have in my collection a plate of diamond which was cleaved into two pieces: as the result of the cleavage, one part was freed from birefringence and is now perfectly dark between crossed nicols, while the other part continues to show a marked restoration of light. It is clear from all these facts that the belief entertained by some writers that a condition of

strain is an inherent characteristic of diamond is completely without foundation.

Examination of the specimens in my collection also shows the lack of foundation for the idea which has gained currency in the literature that diamonds whose transparency extends into the ultra-violet beyond 3000 Å are strain-free, while those which transmit radiations only up to 3000 Å are subject to strains. Actually, I have several specimens of the less transparent variety which appear quite dark between crossed nicols, while the four plates of the more transparent kind in my possession all exhibit an intense restoration of light when viewed under the polarising microscope.

4. The Scattering of Light in Diamond

Beliefs in arbitrary or artificial hypotheses, however plausible they may appear, is contrary to the spirit of science which should rely rather on well-ascertained facts of observation as the foundation of its activities. Galileo when he made his famous experiment of dropping weights from the leaning tower of Pisa, showed the way to deal with all such *ad hoc* beliefs, namely, to confront them with the results of a direct experimental test. Diamond which is the prince of crystalline solids gives us the means of making such tests of the assumptions on which Debye's theory of specific heat and the so-called lattice theory of Born are based.

The spectroscopic examination of the light scattered by a crystal when it is traversed by a beam of monochromatic radiation is perhaps the simplest of the experimental methods available for investigating the possible modes of atomic vibration in a crystal. Diamond is readily examined in this way and yields very interesting results. Even with tiny diamonds, the spectroscope records a remarkably intense and perfectly sharp line displaced from its parent radiation by 1332·1 wave-numbers at room temperature. Bhagavantam (1930) has shown that this line is many times more intense than the sharp bright line with a displacement of 992 wave-numbers observed with benzene which arises from the symmetric vibrations of the carbon ring. Using an exceptionally fine and clear diamond 20 carats in weight, he also recorded several other comparatively faint lines, their wave-number shifts being 1158, 1288, 1382, 1431, 1480, and 1585. More recently, Nayar (1941) has studied the scattering of light in diamond over a wide range of temperature and finds that the principal line remains sensibly sharp over the whole range from 83° T to 1130° T; its frequency-shift, however, falls from 1333·8 at the lowest to 1316·4 at the highest temperature of observation.

The appearance of no less than seven discrete frequencies as sharp lines in the spectrum of such a simple crystal as diamond is not easy to reconcile with the ideas underlying the Debye and Born theories of the solid state. If we lay aside the preconceived notions underlying these theories, the plain reading of the experimental facts is that the infra-red vibration spectrum of diamond is essentially similar to that of a polyatomic molecule and consists of discrete monochromatic lines. The experiments do not offer any *prima facie* support for the assumption inherent in the theories of

Debye and Born that the lattice spectrum is a continuous one.

5. The Blue Fluorescence of Diamond

The experimental situation becomes even clearer in the light of the facts revealed by the recent studies of Nayar (1942) of the blue fluorescence spectrum of diamond and of the corresponding absorption spectrum observed with the crystal held at liquid air temperature. Both in fluorescence and in absorption, diamond when so cooled down exhibits a close doublet centred at 4152 A in the spectrum, the same appearing bright in fluorescence and dark in absorption. Spreading out towards lower frequencies in fluorescence and towards higher frequencies in absorption, appears depicted the lattice spectrum of diamond; this is located with perfect mirror-image symmetry of frequency respectively on the two sides of the 4152 doublet. Even at liquid air temperature, the width of the 4152 band is sufficiently small to enable the details of the lattice spectrum to be seen clearly resolved. No fewer than 19 discrete frequencies can be made out, the values derived from the fluorescence and absorption spectra being in complete agreement. These frequencies range from 1387 wave-numbers down to 178 wave-numbers, and include (within the limits of experimental error) those found by Bhagavantam from his studies on light-scattering in the same region.

Three distinct methods of spectroscopic study, namely, scattering, fluorescence, and absorption, thus agree in indicating that the lattice spectrum of diamond is essentially similar to that of a polyatomic molecule, consisting of a series of discrete monochromatic frequencies. The experimental facts are evidently irreconcilable with the basic ideas of the Debye and the Born theories of the solid state according to which the diamond lattice should have a continuous spectrum of frequencies.

Fig. 1
Blue and green fluorescence spectra

6. X-Ray Reflections of the Second Kind

The spectroscopic evidence showing that the vibration spectrum of diamond consists of discrete monochromatic frequencies has very important consequences for the X-ray physics. Since diamond has a rigid structure which is a three-dimensional repeating pattern in space, each of the possible vibrations of this structure must be assumed to occur in the same way in all the volume elements chosen as the units of the space-pattern, since otherwise we would have an infinite number of possible frequencies, instead of a finite number of discrete vibrations as actually observed. In other words, a diamond in which the atoms oscillate with any one of its infra-red frequencies continues to be a three-

dimensionally periodic structure in space. Thus, for the same reason which enables the crystal planes of the static crystal to give the well-known Laue and Bragg reflections of unaltered frequency, the crystal planes of the vibrating crystal should also give dynamic reflections with altered frequency.

FIG. 2

The triple quantum X-ray reflections

It has been shown by Dr. Nilakantan and myself that the (111) crystal planes in diamond do exhibit dynamic X-ray reflections of the kind indicated above and that their characters as actually observed in experiment, namely, their perfectly specular sharpness, the geometric law which they follow and their practical independence of temperature, can only be understood if they are associated with the high-frequency infra-red vibrations of the crystal structure in the manner suggested. Indeed, exact experimental studies have confirmed this view of their origin in a most remarkable and complete fashion. In particular, it may be remarked that the theory indicates that corresponding to the principal or 1332 vibration of the diamond lattice, the (111) planes should give *three* quantum reflections and not one, the geometric position of these varying with the setting of the crystal, being strictly calculable when it is known. The beautiful confirmation of this prediction furnished by the experiments is illustrated in the accompanying Laue diagram obtained by R. V. Subramanian, where the three quantum-reflections appear as sharply defined lines in displaced positions on one side of the usual Laue reflection.

An important feature of the new X-ray reflections observed with diamond is that the crystal-spacing associated with such reflections, if calculated on the basis of the ordinary Bragg formula, is not constant but varies rapidly with the setting of the crystal. It is also a function of the wave-length of the X-rays employed. Further, the orientation and azimuth of the plane in which the reflections are observed are also dependent on the setting of the crystal and the wave-length of the X-rays. These facts and especially the existence of three simultaneous reflections in geometric relation to each other are in complete accord with the dynamic view of their origin. It is evident, on the other hand, that attempts to explain away these phenomena by *ad hoc* assumptions, *e.g.*, an arbitrarily postulated inherent static "strain" in diamond are wholly inadmissible and indeed quite meaningless. It should be emphasised also that the perfect sharpness at all settings of the crystal exhibited by these reflections excludes any attempt to explain them as due to the disturbance of the crystal lattice by vibrations of the kind assumed in the Debye and Born theories of the solid state.

7. THE LATTICE SPECTRUM OF DIAMOND

The spectroscopic and X-ray results obtained with diamond and briefly summarised above thus compel us to reject the Debye and Born theories as incompatible with the facts. We may summarise the experimental

situation by stating that the possible vibrations of the crystal lattice of the diamond are spectroscopically similar to those of a polyatomic molecule, while geometrically they must be considered as repeating themselves in space with three-dimensional periodicity. A simple way of reconciling these results is to regard the entire crystal as an aggregate of interpenetrating space-lattices of a very simple kind, and to assume that these lattices oscillate as rigid wholes relatively to each other, while their common centre of gravity remains at rest. Such an oscillation would cause the structure of the crystal to vary with time periodically, while retaining its perfect three-dimensional periodicity in space. This picture is, however, only an idealisation, since the X-ray results show that a slow variation of phase of the lattice oscillation at different parts of the crystal is permissible.

The crystal structure of diamond is well-known, and the various possible normal modes of vibration of the lattice which can arise in this way can therefore be theoretically ascertained. Their frequencies can also be calculated in terms of the force resisting the movements of the carbon atoms, namely, those involved in an alteration of the length of the valence bonds and those resisting a change of the angles between them. The lattice spectrum of diamond can thus be theoretically worked out and compared with the experimental data. In particular, it becomes clear that the vibration having a frequency of 1332 wave-numbers is that in which the adjacent planes of carbon atoms parallel to the (111) faces of diamond alternately approach and recede from each other. It is readily understood why such an oscillation results in an intense reflection of the X-rays with altered frequency by those planes. Other lattice frequencies observed in the fluorescence spectrum may be similarly identified as various types of oscillations relative to each other of the atomic planes parallel or perpendicular to important faces of the diamond, *e.g.*, the cube, the octahedron and the dodecahedron. A complete account of the X-ray phenomena exhibited by diamond would include a detailed consideration of the effects of each of these possible modes of oscillation on the lattice planes capable of giving sufficiently strong X-ray reflections.

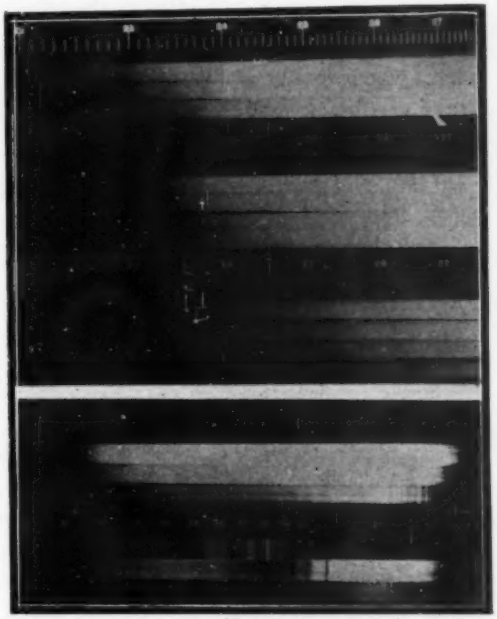

FIG. 3
The absorption spectra of different diamonds

8. THE ABSORPTION SPECTRUM OF DIAMOND

It has already been mentioned that the blue fluorescence of diamond is associated

with a corresponding absorption in the violet and near ultra-violet regions of the spectrum. The intensity of this fluorescence and of the corresponding absorption varies enormously from diamond to diamond, though their spectral characters remain otherwise sensibly the same. For instance, in a small octahedral diamond in my possession, the 4152 band is only recorded after extremely prolonged exposures. The fluorescence, when present, is accompanied by phosphorescence in the green, yellow and red regions of the spectrum. Several of the Panna diamonds in my collection, on the other hand, show an intense fluorescence in the green, yellow and red regions, the blue fluorescence though present being weak in comparison. There are other diamonds again which show both the blue and green fluorescence in roughly comparable intensities.

These remarkable variations in the luminescence properties of diamond appear to bear a relation, not yet fully elucidated, to the equally obvious variations in the transparency of diamonds in the visible and ultra-violet regions of the spectrum. So far as transparency in the ultra-violet is concerned, Mr. Nayar's studies show that at least *three* distinct kinds of variation should be recognised, as they are accompanied by clearly recognisable features in the absorption spectra. *The first and most transparent kind of diamond* has a sharp cut-off at about 2250 A.U. in the ultra-violet. The *second type* has a clearly marked absorption band at about 2370 A.U. followed by a very feeble transmission at shorter wave-lengths. The *third type* has a cut-off at about 3000 A.U., accompanied by subsidiary absorption bands at longer wave-lengths. The majority of diamonds appear to belong to the third type, a characteristic of which is the emission of the blue fluorescence with greater or less intensity. It is noteworthy also that some diamonds exhibit simultaneously more than one or even all the three types of spectroscopic behaviour. A continuous transition between the three types of behaviour is thus shown to be possible. The ultra-violet absorption of the third or ordinary type has been pretty fully investigated by Nayar. No fewer than some 25 sharply defined electronic absorption frequencies have been recorded by him between 3000 A.U. and 3600 A.U. at liquid air temperatures.

9. Concluding Remarks

It will be obvious from what has been stated above that the investigation of the physics of the diamond is full of promise for the future. I have made no reference in this article to further results of great interest which have been obtained but which could not appropriately find a place in a general account of the subject. I may, however, briefly mention the progress which has been made in the study of the relations between the spectroscopic behaviour of different specimens of diamond and the X-ray phenomena exhibited by the same specimens. It is sufficient here to remark that the results obtained in this connection do not in any way contradict the broad results stated above, but on the other hand afford them the fullest support.

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PULSATIONS OF VARIABLE STARS

BY

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ASTRONOMERS are of the opinion[1] that the standard type of a variable star has approximately a spherical symmetry, and any observed phenomenon will look the same from all directions and will not depend on the position of the observer. So the rotational theory of Jeans[2] suggesting that changes in brightness depend on the rotation of a pear-shaped body is ruled out, as a pear-shaped figure has no spherical symmetry. Moreover from spectroscopic observations we find that Cepheid Variables show the strange phenomenon of lurching towards us when they are bright and away from us when they become faint. The accepted interpretation of this phenomenon first suggested by Shapley is that Cepheid Variables pulsate. This theory now holds the field as the best working hypothesis.

Cepheids are also giant stars, and according to Gamow,[3] the pulsation phenomenon observed for Cepheid Variables is due to "instability during the transition from the giant branch into the main sequence". Gamow further opines that "the energy production in ordinary Cepheids is due to hydrogen reactions with lithium, beryllium, and boron (for different values of periods) whereas the only source of energy in the long-period variables is given by the reaction between hydrogen and deuterium".

Eddington[4] considered small radial oscillations of a variable star conforming to the standard model of polytropic index 3, which are symmetrical about the centre and the square of whose amplitude could be neglected. The oscillations were assumed to be adiabatic. Sterne[5] has considered specific cases of small radial oscillations of a star of uniform density and also of a star in which the density varies inversely as the square of the distance from the centre up to a very small distance from the centre within which the density is constant. He neglected the square of the amplitude. It is found that only a sequence of modes of oscillations is possible in these cases.

The author[6] has investigated possible modes of oscillations by retaining the square of the amplitude in the differential equations. He has considered two models of a star, *viz.*, (1) a star of uniform density and (2) a star in which the density varies inversely as the pth power of the distance from the centre (where p is a positive integer excluding 1 and 3), except in a small finite core of constant density surrounding the centre. In both the cases it is found that the amplitude increases and becomes infinite at the boundary of the star, and consequently no mode of radial oscillations is possible. If we assume spherical symmetry for the star, p can have only even integral values; so we can exclude the values 1 and 3. Following the method of the author, H. K. Sen[7] has more recently shown that the solutions of the differential equations would be divergent at the boundary of the star for values of p greater than 3 even if we neglect the square of the amplitude. For $p = 2$ the oscillations would be stable only for a vanishing central core. In this case there will, however, be a singularity at the centre. To avoid this, Sen[7] has taken the following laws of density: (1) $p = a - br$ and (2) $p = a - br^2$. He has found that the radial oscillations are unstable. So we are led to the conclusion that our pulsating stars should be more or less homogeneous. The necessity for the Cepheids to be more homogeneous than "ordinary stars" has been emphasised by Eddington.[8] According to Chandrasekhar,[9] "the Cepheids and the Cluster-type Variables which occur in the "super-giant" region of the Hertzsprung-Russell diagram must be much less concentrated towards the centre than the typical main series stars". Kopal[10] opines that "with advancing spectral type the central condensations of stars seem rapidly to diminish, and the δ Cephei-F5 stars seem to approach the limit of homogeneity". So there is a unanimity of opinion among the astrophysicists that the Cepheids are more homogeneous and much less centrally condensed than the typical main series stars. Dynamically we have also come to the same conclusion.

The author has shown[6] that a passing star may bring about some sort of resonance phenomenon by increasing the amplitude of pulsation through tidal influence and

thereby making the system unstable. The author's Cepheid theory of the origin of the Solar System has already been explained by H. K. Sen in a recent note to *Current Science*.

When a star is rotating about an axis through its centre, it assumes more or less an oblate spheroidal form. It has been found that a sequence of modes of small radial oscillations is possible for a slowly rotating oblate spheroidal Cepheid of small ellipticity if we retain terms only up to the order of the square of the angular velocity.[7] If due to loss of radiant energy the Cepheid begins to contract, the angular velocity would increase and the star would assume a more and more oblate shape causing an appreciable departure from homogeneity. The amplitude would increase, and the oscillations would become unstable. The Cepheid would then break up by fission[11] into two comparable, approximately homogeneous masses. This would give birth to a double star system. On the other hand, we have seen[6] that a passing star due to its tidal influence would help in the formation of a planetary system out of a pulsating Cepheid variable. It is significant that Kopal's investigations[12] have led him to conclude that "the components of a new-born binary are homogeneous or nearly so".

[1] Merrill, P. W., "The Nature of Variable Stars," 1938, p. 116.

[2] Jeans, J. H., "Astronomy and Cosmogony," 1929, p. 388.

[3] Gamow, G., *Phys. Rev.*, 1939, **55**, 718.

[4] Eddington, A. S., "The Internal Constitution of the Stars," 1926, pp. 186–208.

[5] Sterne, T. E., *M.N.*, 1937, **97**, 582.

[6] Banerji, A. C., "Instability of radial oscillations of a variable star and the formation of the planetary system," *Trans. Nat. Inst. Sci. India.* (In the press.)

[7] Sen, H. K., "Radial oscillations of a variable star"; "Adiabatic pulsations of the Cepheid variable"; and "Radial oscillations of a slowly rotating star". Communicated to the *Nat. Acad. Sc. India.*

[8] Eddington, A. S., *M.N.*, 1932, **92**, 480.

[9] Chandrasekhar, S., *ibid.*, 1936, **96**, 656.

[10] Kopal, Z., *ibid.*, 1938, **99**, 38.

[11] Jeans, J. H., "Astronomy and Cosmogony," 1929, p. 266.

[12] Kopal, Z., *M.N.*, 1936, **96**, 862.

SUGAR INDUSTRY OF INDIA, 1939–40*

THE year 1939-40 was an eventful one for Indian Sugar Industry. An excellent crop, a higher ruling price for sugar, and a longer duration of milling season in the U.P. and Bihar resulted in a high record for sugar production. The fixation of a minimum selling price for all grades of sugar by the Indian Sugar Syndicate and a poor demand for sugar in the early part of the season led to the accumulation of abnormally heavy stocks in factory go-downs and the situation was not eased until the Government withdrew the recognition of the Syndicate. Subsequently, however, the Syndicate was re-recognised subject to some conditions. The Syndicate's action in lowering the basic and the selling prices, and the Government's announcements regarding the restriction of output in the year 1940-41 improved the demand for sugar. During this season a sliding scale connecting the cane prices with the prevailing sugar prices was also instituted.

The total area planted with sugarcane this year was 3,619,000 acres which shows an increase of 16 per cent. over the previous year's planting. Leaving Bihar, Assam, Orissa and the C.P., the weather conditions in other cane tracts were not quite favourable.

Out of a total of 158 sugar factories existing in India, 145 worked during the season 1939-40 and produced 1,241,700 tons of sugar which is the highest record production for the industry in India, the previous record being 1,111,400 tons in 1936-37. The short production of sugar in 1938-39 necessitated very heavy imports from Java which took place in the official year (April-March) 1939-40. The quantity of sugar available for consumption in the year under review has been estimated at 1,074,000 tons.

The net production of gur in India in 1939-40 was 2,441,000 tons which is about 15 per cent. in excess of the production in the previous year. The production of molasses in the country was 485,300 tons by cane factories, 16,900 tons by gur refineries and 125,000 tons by khandsaris. Therefore the total production was about 625,000 tons as against 349,000 tons in the previous year.

The rate of excise duty of sugar was raised from Rs. 2 to Rs. 3 per cwt. and correspondingly the import duty on sugar became Rs. 9-12-0 as against Rs. 6-12-0 in the previous year.

The chief feature of Indian sugar industry at present is the large extent of Government control to which it is subjected specially in the U.P. and Bihar. In these provinces the industry has voluntarily submitted itself to this control. In almost all important sugar-producing countries this industry is subject to some form or other of Government control but in the U.P. and Bihar this control is exercised on established lines that have been tried with success elsewhere.

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* Review by R. C. Srivastava, *Supplement to the Indian Trade Journal*, May 7, 1942.

A TEST OF SIGNIFICANCE FOR MULTIPLE OBSERVATIONS

BY

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1. A test of significant discrimination between two sample-groups of multivariate observations can be made by Hotelling's extension[1] of Student's t-test; by R. A. Fisher's discriminating function[2] based on the multiple correlation coefficient; the generalized distance[3] of Mahalanobis, Bose and Roy. In addition to these closely related T^2, R^2, D^2 tests, Wilks[4] has suggested others which would not involve the group means entering into the first three; but these last, as well as D^2 necessitate new sets of tables. For the case of two variates, however, it has been shown[5] that the usual analysis of variance can be carried out exactly, using the z-tables of Fisher, provided the degrees of freedom are suitably readjusted.

Here, I propose to extend the z-test partially to samples drawn from a normally distributed population in $p > 2$ linearly independent variates. I also consider briefly the limiting case in which the number of variates increases beyond any limit, which leads us to discrimination between samples consisting of sets of whole curves. This has the advantage of theoretical simplicity, in that all finite dimensional normal distributions are special cases, in much the same way as polygonal area rules like Simpson's come under the general $\int y dx$ formula. If accepted, the method would extend analysis of variance to such material as electrocardiograms, cranial shapes, temperature curves and the like. It is emphasized that the discrimination is performed by the best linear combination of the old variates, and not by the characteristic roots as such that appear in the process.

The contents of the opening chapters of Courant-Hilbert: *Methoden der Mathematischen Physik I* (1931) are taken for granted in the deduction.

2. We use the tensor summation convention: a repeated index denotes summation over all possible values of the index. The variates 1, 2, ..., p are indicated by Greek indices; sampling values 1, 2, ..., n of each variate by an additional Latin index. Thus $x_{\nu i}$ is the ith sample value of the νth variate. Without loss of generality, the population mean for each variate is taken as zero. The multivariate normal distribution has then the probability density $c\,exp\text{-}\phi/2$ where ϕ is a positive definite quadratic form in the p variates, c a constant so chosen as to make the total probability over the whole p-space equal to unity.

There exist infinitely many linear homogeneous transformations of the variates reducing ϕ to a sum of squares:

$$\phi = \sigma^{\alpha\beta} x_\alpha x_\beta = \delta^{\alpha\beta} y_\alpha y_\beta;$$
$$\delta^{\alpha\beta} = 0,\ \alpha \neq \beta;\ = 1,\ \alpha = \beta. \tag{2.1}$$

$$y_\alpha = a^\nu_\alpha x_\nu,\ |a^\mu_\nu| \neq 0;\ \sigma^{\alpha\beta} = \xi^{\mu\nu} a^\alpha_\mu a^\beta_\nu.$$

The new variates y are therefore uncorrelated, each with unit variance. The method of discrimination proposed is that of applying the z-test in that particular one of the hypothetical y variates for which the observed samples give a maximum value of z. Let this be y_λ. For a sample of n observations, we have:

$$\frac{1}{n}\sum_{i=1}^{n} y_{\lambda i} = \bar{y}_\lambda = \bar{x}_\nu a^\nu_\lambda, \text{ where } \bar{x}_\nu = \frac{1}{n}\sum_{i=1}^{n} x_{\nu i}; \tag{2.2}$$

$$\frac{1}{n-1}\sum_{i=1}^{n} (y_{\lambda i} - \bar{y}_\lambda)^2 = \frac{1}{n-1}\sum_{i=1}^{n} \{a^\nu_\lambda (x_{\nu i} - \bar{x}_\nu)\}^2$$
$$= a^\nu_\lambda a^\mu_\nu s_{\mu\nu};$$

$$\text{where } s_{\mu\nu} = s_{\nu\mu} = \frac{1}{n-1}\sum_{i=1}^{n} (x_{\nu i} - \bar{x}_\nu)(x_{\mu i} - \bar{x}_\mu).$$

The tensors $s_{\mu\nu}$, $s'_{\mu\nu}$ are unbiassed estimates of the normalized cofactors of the population tensor $\sigma^{\alpha\beta}$, calculated from n, n'

random multiple observations respectively. Nothing is to be assumed known as to the actual values of $\sigma^{\alpha\beta}$ or of the normalizing transformation coefficients a^{μ}_{λ}.

3. We now take a new vector variable $u^{\alpha} = a^{\alpha}_{\lambda}$, since λ is to be fixed for the problem in hand. The two quadratic forms $s_{\alpha\beta}\, u^{\alpha}u\beta$, $s'_{\alpha\beta}\, u^{\alpha}u\beta$ are positive definite because all principal determinants in any sampling matrix $||s_{\alpha\beta}||$ calculated as in (2.2) are Gram determinants, which are positive whenever the p variates are linearly independent. Our special discrimination problem is thus reduced to finding the maximum of $F = s'_{\alpha\beta}u^{\alpha}u\beta / s_{\mu\nu}u^{\mu}u^{\nu}$ or of its reciprocal.

The answer to this is well known. All we need here is the greatest relative characteristic root of the two forms, *i.e.*, of the determinantal equation

$$(3\cdot1) \qquad \text{det. } |s_{\alpha\beta} - \vartheta s'_{\alpha\beta}| = 0,$$

or of the reciprocal equation, interchanging s, s'. These roots are all positive. If arranged in descending order of magnitude, they have the minimax property: ϑ^{ν}, $1 < \nu \leqslant p$, is the smallest value assumed by the maximum of F when the u are subjected to $\nu - 1$ independent linear homogeneous restrictions. Thus, all we have to do here is to put $z = \frac{1}{2}|\log\vartheta|$ for the extreme root, using the z-tables of Fisher with degrees of freedom based on the samples alone, as for the single variate. The distribution of the greatest or of any other characteristic root does not enter into the argument, the ratio of the two hypothetically transformed quadratic forms being always that of two sample-variances. What we have obtained is essentially an existence theorem to the effect that the change by means of a suitable linear transformation of co-ordinates (variates) can give a z-value as great as but no greater than the greatest relative characteristic root of the two sampling tensor matrices. So, the z-tables are to be entered with degrees of freedom one less than the number in the samples, in the absence of any other linear restriction on the variates than that incurred in measuring from the sample mean. It might be possible to use the other roots by compounding probabilities, but it must be kept in mind that the minimax property requires that our transformation coefficients, not the variates, be sufficiently unrestricted. For example, our method of deduction cannot be called valid for $p = 1$, $p = 2$, as there are then not enough of the a^{μ}_{ν} left free, for a maximum to exist necessarily, after reducing the population form to a sum of squares. Of course, this is immaterial in view of the fact that $p = 1$ is trivial and $p = 2$ settled by means of a special device.[5] In each of these cases it is true that no *greater* z-discrimination is possible with linear combinations than is indicated by our test.

4. One advantage of the extension is that it holds for any $p > 2$. The ordinary analysis of variance is to be carried out exactly, in view of the fact that any sampling matrix may be broken up into various additive components due to the sources between which one wishes to discriminate. There is the further advantage that in case significant discrimination has been shown, the residual matrix of $||s_{\mu\nu}||$ may be used as the fundamental matrix in Hotelling's T^2 in the same way that the residual estimate of variance is used for Student's t after analysis of variance in a single dimension. The disadvantage is that our test would not be so powerful as others in rejecting H_0 when it is false; H_0 here being the null hypothesis that the various sampling tensors are pairwise compatible estimates of the same population tensor.

One method of calculating the extreme root has been given by Fisher (*SMRW* ex. 46.2) who uses divided differences. But equation (3.1) also lends itself to approximation for the greatest root by means of root-squaring. Where the greatest root is not multiple, the rule can be stated immediately, without going into the very simple proof. We define: $\Delta = |s_{\alpha\beta}|$; $\Delta' = |s'_{\alpha\beta}||$; Θ is the sum of the p determinants formed by substituting in rotation a single row in $\|s_{\alpha\beta}\|$ by the corresponding row of $\|s'_{\alpha\beta}\|$, and Θ' the same function interchanging s, s'. Finally, let Δ_m, Δ'_m, Θ_m, Θ'_m be the corresponding functions constructed by squaring (iteration) m times, according to the rule for matrix multiplication, each of the two matrices. Then an approximate value of z for maximal significance is the greater of

$$(4.1) \qquad \frac{1}{2^{m+1}} \log\left(\frac{\Theta_m}{\Delta_m}\right) \text{ or } \frac{1}{2^{m+1}} \log\left(\frac{\Theta'_m}{\Delta'_m}\right).$$

Approximation is quite rapid when the greatest root is isolated. For a multiple root the ratio Θ/Δ must be divided by a factor corresponding to the multiplicity; a similar precaution should also be taken for roots very close together.

5. Still more interesting is the passage to the limit. Suppose we have to deal with silhouttes taken on the profiloscope. One method would be to take some well-defined point such as the ear orifice for the origin, some well-defined line such as that from the origin to the base of the nose as prime vector, and to expand the distance from the origin to the general point of the profile as a Fourier series in terms of the angle from the prime vector. The co-ordinates would then be the Fourier coefficients; if enough were determined to permit the reproduction of any profile to within the original limits of observation, our test or any suitable multivariate test could be applied directly. Yet this is clearly unsatisfactory in that we are using a finite number of co-ordinates in an indefinite number of dimensions without knowing anything of those discarded. The argument that professional anthropometrists do this or worse in using a finite number of characters instead of our harmonic analyser, without proving normality of the distribution, does not suffice. So, we take the other form of the passage to the limit represented by integral equations.

We keep the original quadratic form, extended to infinitely many dimensions; take the co-ordinates as "Fourier" coefficients associated with expansion in some given set of orthonormal functions defined over $0 \leqslant x \leqslant 1$, which is also to be taken hereafter as the range for all undefined integrations. The probability density will again be represented by $c \exp -\phi/2$, with

$$\phi = \int\int \mathrm{K}(s,t) f(s) f(t)\, ds\, dt\,; \quad \bar{f}(s) = \frac{1}{n} \sum_1^n f_i(s)$$

(5·1)

$$\mathrm{S}(s,t) = \frac{1}{n-1} \sum_1^n \{f_i(s) - \bar{f}(s)\}\{f_i(t) - \bar{f}(t)\}.$$

These now replace (2.1), (2.2) in the function-space, each multiple observation on the variates being taken to define a function $f(x)$ over $0 \leqslant x \leqslant 1$. For significance tests, the reciprocal to $\mathrm{S}(s,t)$ is the best estimate of the population kernel $\mathrm{K}(s,t)$.

An alternative simultaneous visualization of the space is, as before, the Hilbert space of the coefficients in the orthogonal-function expansion of $f_i(x)$ Naturally, it is essential to take the population kernel $\mathrm{K}(s,t)$ as positive, semi-definite or definite; its characteristic functions form the most convenient orthogonal functions to use for theoretical purposes, which amounts to using a quadratic form with diagonal matrix. If the characteristic orthonormal functions do not form a closed set, as many more are to be adjoined as are necessary for closure, taking the additional co-ordinates associated with these extra functions to constitute the orthocomplement to the function manifold of $\mathrm{K}(s,t)$. In probability integrations, these extra co-ordinates will be undetermined, hence to be integrated over the whole of the orthocomplement. This allows all kernels to be considered in a proper function-space, even the degenerate kernels that actually include the ordinary p-variate normal distribution; conversely, the p-variate case may be considered as associated with a degenerate $\mathrm{K}(s,t)$, by ascribing one function of an arbitrary orthonormal set to each co-ordinate as coefficient. For limits of integration, we use the convenient as well as fashionable terminology of lattice theory, taking $f \smile g$, $f \frown g$ respectively as the functions whose "Fourier" coefficients are the greater and the lesser of the corresponding coefficients in the expansions of f and g. Thus, the integration can extend from $f \frown g$ *to* $f \smile g$, and over the whole of the orthocomplement whenever integration "between" two function-limits f, g is to be performed.

6. The trouble with all this is that it has only an appearance of verisimilitude. In a space of infinitely many dimensions, we have as yet failed to define the volume element. If we take the multiple integral over infinitely many dimensions as evaluated by successive iterated integrals in the usual manner, it will be seen that any consistent evaluation making the total probability unity leads in general to zero probability in integrating over any proper sub-manifold of the whole space. One must go much deeper than the intuitive methods of 5. It is seen that if we merely take limits increasing the number of dimensions, the "volume" of a hypercube is 0, 1, or ∞; of a hypersphere zero, as the n-dimensional

sphere has the volume $2\pi^n r^n/n\,\Gamma(n/2) \to 0$ as $n \to \infty$.

This difficulty is surmounted under the hypotheses that the abstract space under consideration has a distance relationship obeying the usual postulates; is separable, locally compact, with a congruence relation. The two middle ones have to remain assumptions, distance r being defined by $r^2=\phi(f-g)$, for any two elements f, g. The space has to be restricted to elements for which $K(s,t)$ is a positive definite kernel. Congruence of two regions may be taken as transformability of one region into the other by some member of a suitably restricted (linear) transformation group, preserving $\phi(f-g)$ and transforming the entire manifold into the entire manifold. Then a Haar measure[7] and a Lebesgue-Stieltjes integral exist. Unrestricted Hilbert space is not locally compact because no infinite sequence of orthogonal functions can converge in L^2.

It follows that all classical results can be stated and proved again in general abstract spaces, though it is better for our purpose to take kernels of the second (Fredholm) kind for some theorems, which means only the addition of a term $\int f^2 ds$ to the ϕ of (5.1). We may then state such results as: *The sum of two normally distributed variates is also normally distributed with mean the sum of the two means and kernel whose (formal) reciprocal is the sum of the two (formal) reciprocals of the given kernels.*

Many fundamental procedures and distributions may be generalized to this space, including some of the more powerful tests considered by P. L. Hsu.[6] Not only can the Hotelling-Fisher formulæ[2] be derived from a degenerate population kernel of p degrees of freedom, but a space of sufficiently large (or infinite) number of dimensions would lead to corresponding formulæ with $p=n$, the degrees of freedom within groups. It is clear, however, that the nature of the fundamental abstract space associated with a given population will not be revealed in general by means of the sample taken by a practising statistician; here, I regret my inability to demonstrate with a practical example, for which there is data enough but no access to the necessary machines: ordinary or cinema integraph, differential analyser, etc. In any case, it is clear that a test which applies independently of dimentionality,[8] without new tables, becomes of importance whether or not more efficient and powerful tests could be devised for the particular unknown population in question. This test is the analogue of (3.1); taking limits, we state it as the problem of locating the extreme characteristic root of $\int \{S[s,t] - \vartheta S'[s,t]\} f dt = 0$. *By* noting that the sample kernels S, S′ are degenerate, this can be reduced to a set of linear equations in a finite number of unknowns, whence the existence of a finite number of positive determinate roots follows at once. It is proposed that the extreme root be used as before for the z-tests; the estimating kernels may still be broken up into additive components, permitting analysis of variance. It would, of course, be convenient to have the distribution of certain sampling functions, as for example of $\int\int S^{-1} S'\, ds dt$, where S^{-1} is the reciprocal to $S(s,t)$.

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[1] H. Hotelling, "The Generalization of Student's Ratio," *Annals of Mathematical Statistics*, 1931, **2**, 360–78.

[2] R. A. Fisher, *Statistical Methods for Research Workers*, 1938, 7th ed., 204–98.

[3] P. C. Mahalanobis, *Proc. Nat. Inst. Sci. India*, 1936, **2**, 49–55; R. C. Bose., *Sankhyā*, 1936, **2**, 143–54, 379–84; S. N. Roy, *Ibid.*, 385–96.

[4] S S. Wilks, "Certain Generalizations in the Analysis of Variance," *Biometrika*, 1932, **24**, 471–94.

[5] D. D. Kosambi, "A Bivariate Extension of Fisher's z-Test," *Cur. Sci.*, 1941, **10**, 191–92.

[6] P. L. Hsu, *Biometrika*, 1940, **31**, 221–37; *Annals of Mathematical Statistics*, 1939, **9**, 231–43; *J. London Math. Soc.*, **16**, 1941, 183–94.

[7] Stefan Banach, in S. Saks, *Théorie de l'Intègrale*, 1933, 204–72.

[8] If the Haar volume of the sphere $\phi(f) \leqslant r^2$ is cr^k, we have the usual k-dimensional space or its equivalent. But we also get fractional dimensionality when k is non-integral. So, the degenerate kernel need not necessarily lead to the ordinary p-dimensional case. For the existence and construction of point-sets with fractional dimension, see F. Hansdorff, *Math. Annalen*, 1919, **79**, 157–79.

A CHEAP ANTI-MALARIAL DRUG IN INDIA

THE history of cinchona cultivation in the British Empire constitutes a tragedy of mismanagement. During the closing years of the last century, India and Ceylon led the world to an extent that over-production occurred and the inevitable crash brought about the extinction of the cinchona industry in the British Empire; but owing to climatic advantages and more scientifically regulated control, the Dutch industry in Java survived. To-day that island has a virtual world monopoly, while India produces 70,000 pounds a year against her real requirements of at least 1,000,000 pounds. Again, as in 1914, India is seriously alarmed at the prospect of a quinine famine in the face of the threat of war. The adoption of some intelligent forward policy in this direction is an urgent matter, but even if cinchona cultivation were immediately extended, appreciable results would not be obtained for at least ten years. With the awakening of interest in the pharmaceutical industry in India, a demand has arisen for the revival of cinchona cultivation. It is not suggested that Java should be ousted from her present position of world monopoly, but that at least India should cater for her own needs. The object of supplying a cheap anti-malarial drug for the people should be kept clearly in mind. Sir R. N. Chopra's recommendation that the Cinchona Department should cultivate on a large enough scale that species of cinchona best suited to the Indian climate has not been acted upon. The main obstacle to the problem of distribution to the needy is the high price of quinine fixed by the Java monopoly.

Even if cinchona cultivation were extended in India, the price would remain relatively high, but it is pointed out in a recent issue of the *Indian Medical Gazette* that a preparation of mixed cinchona alkaloids of the "totaquina" standard could be produced at a cost of one-seventh that of quinine. The "totaquina" standard rivals in efficiency that of pure quinine, and wherever it has been tried out on an extensive scale this has been confirmed, while there are many who believe that the mixed alkaloids are even more efficacious than quinine in certain forms of malaria. This standard originated with the Malaria Commission of the League of Nations as being an efficient anti-malaria drug that could be prepared from the hardier cinchona plants in the form of crystallisable alkaloids mixed in the proportion in which they occur naturally in cinchona bark. It is not generally realised that the preparation known as "cinchona febrifuge" contains the mixed alkaloids remaining after the removal of the valuable quinine, and its universal use in malaria is therefore to be depricated, but the British Pharmacopœia standard for totaquina demands that it shall contain at least 70 per cent. of crystallisable alkaloids, of which at least 15 per cent. shall be quinine. The essence of the whole matter would appear to be that, owing to the failure to realize the urgency and magnitude of the problem, generations of doctors and the public have been educated to believe that only one alkaloid—quinine—is of any value in the treatment of malaria, when, on the contrary, it is probable that powdered cinchona bark gives every bit as good a result and could be manufactured at a price at which universal distribution to the malaria-stricken millions of India would become a possibility.

In 1937, on the recommendation of the Indian Research Fund Association, the Government of India appointed an officer to determine what areas in India are best suited to cinchona cultivation, and what would be the cost of production in such areas. In this investigation the land considered suitable for *Cinchona ledgeriana* has been chosen on the grounds that it yields the maximum quantities of quinine. The contention is that the Government in India should extend their present plantations, still growing the high-quinine-yielding *C. ledgeriana* in suitable areas, grow *C. robusta* and other hardier species in other areas, and in their factories manufacture a large preponderance of totaquina and smaller amounts of pure alkaloids. No real progress can be made, it is argued with some force, until the commercial has been made subservient to the medical point of view.

—From the *British Medical Journal.*

LETTERS TO THE EDITOR

APPLICATION OF X-RAY METHODS TO THE CONFIRMATION OF THE IDENTITY OF ORGANIC COMPOUNDS

The identity of organic compounds is usually shown by the undepressed melting point of mixtures of substances and of mixtures of their similar derivatives. We have used X-ray methods of crystal structure analysis for the confirmation of the identity of 2 : 4 dibromo-6-nitro resorcinol-3-methylether obtained by one of us (M. S.) by bromination and nitration respectively of 5-nitro-2-hydroxy-4-methoxy-benzaldehyde and 3 : 5 dibromo-2-hydroxy-4-methoxy-benzaldehyde. In both cases, on recrystallisation, fibrous acicular crystals were obtained. They were both found to be orthorhombic with one of the crystallographic axes coincident with the length of the needles. Rotation photographs of crystals obtained by both methods were taken, the length of the acicular crystals being parallel to the axis of rotation, using copper K_α radiation and a cylindrical camera of radius 32·03 mm. The identity period obtained from these photographs are $4{\cdot}13 \pm 0{\cdot}02$ Å for the product obtained by nitration and $4{\cdot}11 \pm 0{\cdot}02$ Å for the other. The photographs were also identical in all respects, all the corresponding spots coinciding exactly on superposition of the photographs. Accurate measurements of the co-ordinates of the more prominent spots made on one photograph were found to be in agreement with those on the other within the limits of errors of measurement. These results confirm the identity of the two products obtained as indicated above.

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M. Seshaiyengar.

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and
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Bangalore,
April 14, 1942.

A NEW BAND-SYSTEM OF BORON MONOXIDE

A preliminary note on some continuous diffuse bands (fluctuation bands) obtained in the spark between glass electrodes reported the presence of discrete bands among some of the fluctuation bands.[1] An analysis of these discrete

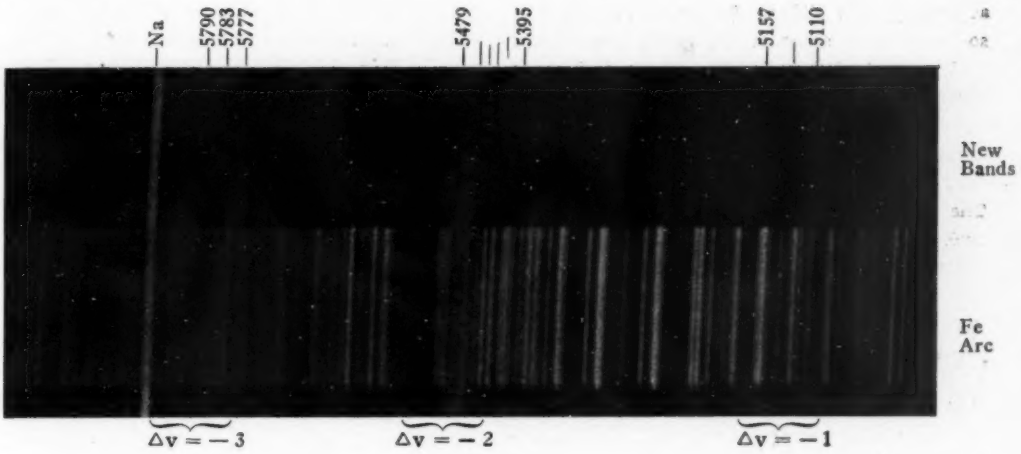

FIG. 1

bands has now been done, which shows that they form a new electronic system in the BO molecule. As a result of this analysis it has been further found out that the diffuse fluctuation bands are not due to SiO_2 but are the well-known so-called boric oxide bands.[2]

It will be seen from Fig. 1, which is an enlarged reproduction of a spectrogram of the radiation from a Bunsen burner fed with boric acid, taken on a constant deviation glass spectrograph, that there are at least three groups of bands which form three sequences. These when arranged in the v'v" array yield the following $\Delta v''$ values given in Table I, where the $\Delta v'$ values[3] for the β-bands of $B^{11}O$ are also included.

TABLE 1

Vibrational Term Differences

Levels	0—1	1—2	2—3	3—4	4—5	5—6	6—7
Initial of β bands of[3] $B^{11}O$ = $\Delta v'$	1259	1237·8	1217·4	1198·6	1179·1	1160·7	—
Final of the new system = $\Delta v''$	—	—	1225	1206	1174	1162	1142

The agreement between the two sets of values indicates first, that the electronic levels of which these are the vibrational term differences are identically the same and secondly, that the first term difference observed in the new bands is already the one between the second and the third vibrational levels of BO in this common electronic state. On this basis the following expression is derived for the wave-numbers of the band heads of the new system:—

$$\nu_{head} = 21005{\cdot}6 + (1200\ v' - 15{\cdot}4\ v'^2) - (1266\ v'' - 10\ v''^2).$$

The O,O band has not been observed but the v' numbering also seems certain. The expression further shows that the final vibrational function $(1266\ v - 10\ v^2)$ of the new system is, within the limits of allowable error, the same as the initial of the β bands of $B^{11}O$ $(1268{\cdot}8\ v - 9{\cdot}98\ v^2)$. The new electronic level is thus located at $\nu = 63870{\cdot}8$ cm.$^{-1}$ (21005·6 *plus* 42865·2 the origin of β bands) or 7·9 e.v.

These bands are not usually obtained in the method of production (active nitrogen *plus* BCl_3 vapour) employed for the development of the α, β and combination band-systems of BO. Also the latter band-systems are not developed, except for possible traces of some of them, either in the boric acid flame or the spark discharge. The new bands, however, always

accompany the diffuse fluctuation bands, the so-called boric oxide bands, which also appear to be due to BO molecule. These and other considerations pertaining to the diffuse bands indicate that the initial state involved in the new band-system is a Σ, possibly a quartet Σ level, arising out of B ($2s^2 2p^2, {}^4P$) and O ($2s^2 2p^4, {}^1D$). There is further reason to think that probably such a state of BO is directly reached when the molecule is obtained from B_2O_3.

It is remarkable, however, that the spectrograms which show these diffuse fluctuation bands in the glass spark do not show any trace of the resonance lines of boron. It is evident that for detection of boron in the form of B_2O_3 or boric acid, these bands are much more sensitive than the *raies ultimes* of boron. The glass used was supposed not to contain any chemically traceable boron.

Details regarding these and other points will be published elsewhere. I am grateful to Prof. R. K. Asundi for helpful discussion and continued interest in the work.

NAND LAL SINGH.

B/1 Quarters,
Benares Hindu University,
June 12, 1942.

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[1] *Proc. Ind. Sci. Congress, Benares*, 1941, 29, Part III.

[2] *Handbuch der Spectroscopie*, 1910, Band V, 138. (Kayser).

[3] *Phys. Rev.*, 1925, **25**, 59.

A NOTE ON THE ISOLATION OF THREE NEW BITTER PRINCIPLES FROM THE NIM OIL

THE active constituents of the Nim oil have interested a number of workers since Chatterji and Sen[1] reported the isolation of the so-called 'margosic acid' from it, in 1919. The investigations on this problem have, however, led to findings of a very conflicting character. Thus the margosic acid, which was considered to be the active principle of Nim oil was later shown to be mainly a mixture of fatty acids.[2] In 1923, Watson and co-workers,[3] isolated from the soap lye of the oil a sulphur-free crystalline bitter acid 'margoso-picrin', in a yield which works out to 0·012 to 0·017 per cent. on the weight of the oil and amorphous bitter acids in a yield of ca. 0·15 to 0·24 per cent. Sen and Banerji[4] noted the isolation of a sulphur containing acidic bitter principle from the aqueous extracts of the oil (yield not mentioned). More recently Quadrat-i-khuda and co-workers[5] communicated the isolation of the sulphur-containing essential oil and an amorphous, water-soluble bitter principle from the aqueous extracts of the oil, after previously subjecting it for long periods to steam distillation for removal of the steam voltaic products.

The methods employed by Watson and co-workers as well as by Q. Khuda and co-workers for the isolation of the active principle, appear to be of too drastic a character to ensure the isolation of the bitter principle in its native condition. In view of the growing importance of the Nim oil as a commercial product and the long established uses of Nim in the indigenous systems of medicine as a bitter tonic, an anti-malarial and anthelmintic, and as a cure for syphilitic conditions and a variety of skin diseases, a re-investigation of the active principle of the oil was considered of interest, as part of a general scheme of research for establishing its industrial uses.

Working on a so far unexplored plan of exclusively mechanical separation of the various constituents of the Nim oil, the following well-defined bitter constituents have been isolated from it, the total bitter constituents being obtained in an industrially workable yield of ca. 1·2 per cent. as against 0·24 per cent. reported by Watson and co-workers:

(1) A sulphur-free, neutral, water-insoluble, colourless crystalline product melting at 205° C. and provisionally named as 'NIMBIN'. Yield—0·1 per cent. on the weight of the oil.

(2) A bitter principle of similar characteristics as 'NIMBIN' melting at 192° C., which has been provisionally named as 'NIMBININ'. Yield—0·01 per cent. on the weight of the oil.

(3) A cream-coloured, water-insoluble, granular powder of neutral character, provisionally named as 'NIMBIDIN'. M.p. 90-100° C. Yield—1·1 per cent. on the weight of the oil.

In the process of isolation of the bitter principles, a treacly sulphur-containing product has also been obtained and is being studied further.

The bitter constituents mentioned above, are quite distinct from the acidic or water-soluble bitters reported by earlier authors, as they are all of them neutral in character and insoluble in water. Owing to their insolubility in water as well as in the alkaline saliva they are nearly tasteless in powder form. Their colloidal solutions in alcohol-water, however, are intensely bitter, 'NIMBIDIN' being perceptibly bitter in dilutions upto 1 in 100,000 with the characteristic bitterness of fresh Nim twigs. On mild hydrolysis 'nimbidin' and 'nimbin' yield acidic and partly water-soluble bitters. The combustion value indicates an empirical composition of $C_7H_{10}O_2$ for 'nimbin'. The main bitter principle of the Nim oil, 'nimbidin', which is amorphous and for which, therefore, only a limited degree of uniformity can be claimed, appears to contain sulphur not as an impurity but as a part of its constitution. This point, which is being further investigated, is of exceptional interest in view of the fact, that all the bitter principles of Nim oil reported by earlier authors have been noted to be free from sulphur, with the exception of the sulphur-containing bitter acid reported by Sen and Banerji.[4]

The method employed for the isolation of the bitter products does not involve the initial saponification of the oil and is based on the difference in the solubilities of its various constituents in dilute alcohol and other non-miscible organic solvents like ether, petrol-ether and ethyl acetate. Apart from the fact that such a method ensures the isolation of the constituents in the form in which they are present in the oil, it has the further advantage of yielding a comparatively purified oil which could be used in the soap manufacture or for any other industrial purposes.

From the preliminary bacteriological tests, it appears that nimbidin is the main active constituent of the Nim oil. A systematic chemical and pharmacological study of the isolated products is now being carried out under a definite scheme of the Drugs Committee of the Council of Scientific and Industrial Research, for the investigation of Nim oil with reference to its active constituents and its general industrial utilisation.

S. Siddiqui.

Laboratories of the Director,
Scientific and Industrial Research,
University Buildings,
Delhi,
June 10, 1942.

[1] *Ind. Med. Gaz.*, **1919, 54,** 174.

[2] A. Roy and S. Datt, *Jour. Soc. Chem. Indus.*, **1929,** 333T.

[3] —, *Ibid.*, **1923, 42,** 387T.

[4] *Jour. Ind. Chem. Soc.*, **1931,** 773.

[5] *Ibid.*, **1940,** 189.

CHEMICAL TEST FOR DETECTION OF ARGEMONE OIL

In view of the importance of argemone oil in the ætiology of epidemic dropsy as worked out by Lal *et al.*[1] with whom the author was also associated, the recent work on a sensitive chemical test with ferric chloride by Sarkar[2] for detection of argemone oil alone or in solution with mustard oil up to the concentration of 0·75 per cent. is of interest.

The use of $FeCl_3$ as a reagent for characteristic colour reaction with some alkaloids, *e.g.*, morphine, mixed ipecacuanha alkaloids, colchicine, etc.,[3] is well known. The precipitate obtained in the $FeCl_3$ test of argemone oil has been found by the author to be due to a new alkaloid present in argemone oil and which has been isolated by Mukherji, Lal and Mathur[4] by saponification (W.C.S.) and hydrochloric acid extraction (C.F.B.) of it. Some other common alkaloidal reagents like Mayer's and Wagner's have also been tried with satisfactory results.

The sensitivity of the $FeCl_3$ test as suggested by Sarkar is, however, affected for two reasons, namely, (a) an emulsion of acid and oil resembling a precipitate is already formed at the acid-oil interface before addition of $FeCl_3$ solution, and (b) the oil-layer absorbs some amount of precipitate obtained by the addition of $FeCl_3$. The following modification has been found to have improved the test.

Instead of adding $FeCl_3$ solution straight to the mixture of oil and acid, the acid layer is first separated by centrifugation. To 1 c.c. of this acid extract which should be absolutely free from any oil globules 4 to 5 drops of $FeCl_3$ solution (10 per cent.) is added. The rest of the test is practically the same as carried out by Sarkar except that the addition of ethyl alcohol is omitted as it has been found to be of no use. After the test is thus modified it can detect argemone oil to a concentration of 0·2 per cent. or even less.

The author considers that from the practical and Public Health points of view HNO_3 test is quite satisfactory and $FeCl_3$ test may also be adopted on qualitative basis. But before the latter is finally accepted as a specific test for argemone oil as claimed by Sarkar more elaborate work would be necessary.

My best thanks are due to Lt.-Col. S. S. Sokhey, Director, for his kind interest in this work.

S. P. MUKHERJI.

Haffkine Institute,
Bombay,
June 22, 1942.

[1] Lal, R. B., Mukherji, S. P., Roy, S. C., and Sankaran, G., *Ind. Jour. Med. Res.*, 1939, **27**, 207.

Lal, R. B., Mukherji, S. P., Das Gupta, A. C., and Chatterji, S. R., *Ibid.*, 1940, **28**, 163.

Lal, R. B., and Das Gupta, A. C., *Ibid.*, 1941, **29**, 157.

Lal, R. B., Das Gupta, A. C., Mukherji, S. P., and Adak, B., *Ibid.*, 1941, **29**, 839.

[2] Sarkar, S. N., *Curr. Sci.*, 1941, **9**, 405; *Ann. Biochem. Expt. Med.*, 1, 271.

[3] Mitchell, C. A., Allen's *Commercial Organic Analysis*, 1929, **7**, 5th ed., 39.

[4] Mukherji, S. P., Lal, R. B., and Mathur, K. B. L., *Ind. Jour. Med. Res.*, 1941, **29**, 361.

EGGS OF THE GOAT WARBLE-FLY (*HYPODERMA CROSSII* PATTON)

CROSS (cited by Patton, 1922) was the earliest to record the occurrence of the goat warble-fly in India. He collected large numbers of larvæ and adults of this species from the Salt Range area of the Punjab. Patton, in 1922, described this species and named it after Cross. Soni (1939, 1940) published a detailed account of the morphology of the young and full-grown larvæ and also observations on the bionomics of the same pest.

India produces one-third of the total production of goat-skins in the world and, in view of the great damage caused to this commodity by the goat warble-fly, it is essential that more should be known about its life-history and bionomics. A perusal of the available literature on the subject shows that the eggs of the species of *Hypoderma* have not been

FIG. 1

Eggs of *Hypoderma crossii* ×11·25

encountered. Patton (1922) observes: "It is just possible that the female *Hypoderma crossii* lays her eggs directly on the long hairs on the sides of the goats, and that the larvæ enter the skin below and remain there, and that there is no migration as in the case of *H. bovis* and *H. lineatum*. Captain Cross tells me he

has never found any eggs on the hairs of the legs of the goats he has examined."

During my recent survey of Jhelum district in the Punjab and Kulu valley I came across the eggs of *H. crossii* attached to the hair on the back of the goats of the 'Barbary' breed. The eggs were invariably found on the underside of the hair where they were protected from direct contact with environmental factors. Like *H. lineatum* and unlike *H. bovis* the eggs are attached in rows to a single hair, each egg being at an angle of about 45° to the axis of the hair. The egg is of a dull yellowish-white colour and the surface smooth and shining. It is ovoid in shape and slightly broader at the base than at the tip. The average length of the egg is 0·75 mm. and the average breadth at its greatest thickness 0·2 mm. The tip of the egg has a slight transverse ridge, along which the egg splits during hatching. The clasp with which the egg is attached to the hair is oval in outline. Its most characteristic difference from the egg of *H. lineatum* and *H. bovis* is the absence of a petiole or stalk between the clasp and the egg proper (Fig. 1).

B. N. Soni.

Imperial Veterinary Research Institute,
Mukteswar-Kumaun, U.P.,
June 9, 1942.

[1] Patton, W. S., *Ind. J. Med. Res.*, 1922, **10**, 573.

[2] Soni, B. N., *Ind. J. of Vet. Sci. & Anim. Husb.*, 1939, **9**, 367.

[3] —, *Ibid.*, 1940, **9**, 280.

[4] —, *Ibid.*, 1940, **10**, 291.

ON THE PRESSOR EFFECT OF ADRENALINE POWDER

The rotation of a sample of adrenaline powder is believed to indicate the purity of this compound; but many samples showing lower rotation with the sodium line are being found on physiological assay on decapitated cats to correspond to almost 100 per cent. of the powder (sample No. 1) which has satisfied all the purity tests as described in the British Pharmacopœia. Again some samples of natural origin though not so pure from B.P. tests, offer better response so far as the rise of blood pressure in animals are concerned. A particular synthetic product (sample No. 4 in the table) although rotates the plane of polarisation of light to a considerable degree was found to be much inferior in biological strength.

TABLE I

Sample	Origin	Melting point	Specific rotation B.P. Method	Assay	
				Chemical[1]	Biological
1	Synthetic	210° C.	— 52·2°	100%	100%
2	Do.	207-208	— 48·3	99	100
3	Do.	207	— 46·8	101	100
4	Do.	207	— 49	95·5	88
5	Do.	201	— 49·5	101·0	100
6	Natural	—	—	—	106
7	Do.	199-201	— 43	98	111
8	Do.	Indifferent	Too coloured solution	75	110

All these tend to raise two questions—one is that a powder equivalent in biological potency to any standard adrenaline may be of inferior quality from purity tests. This suggests that a more elaborate and detailed criteria should preferably be established for the evaluation of the properties of an adrenaline powder that be suitable for preparing Liquor Adrenalinæ Hydrochloride. The other point is whether a powder from natural sources as commercially available contain substance or substances (even in trace) that may produce a synergistic effect on the sympathomimetic action of the drug. Work in this Laboratory is in progress to find out whether the fractions during the course of extraction of the active principle from suprarenal glands exert any synergic effect on the pressor activity of the final purified powder.

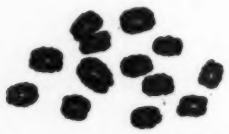
A. N. Bose.
S. K. Ganguli.

Bengal Immunity Research Laboratory,
Calcutta,
June 19, 1942.

[1] Folin, Cannon and Denis, *J. Biol. Chem.*, 191, **133**, 479.

CHROMOSOME NUMBER IN *TINOSPORA*

WHILE examining the pollen mother-cells of *Tinospora cordifolia* Miers, in connection with certain studies on the chromosomes of dicœcious plants, it was observed that the haploid number in this plant is $n = 13$, and not $n = 12$ as previously reported by Joshi and Rao.[1] This count was made by examining pollen mother-cells in acetocarmine and was confirmed by studying a very large number of flower buds from two male plants, while the observations of the above authors were made from fixed and sectioned material. If their observation is correct, it shows the presence of aneuploidy in this species. However, one might expect $n = 13$ as the more likely number in *Tinospora* as the related genus *Menispermum* has $n = 26$ Lindsay[2]). In that case the statement of



Chromosomes of *Tinospora cordifolia* at metaphase of first meiotic division in pollen mother-cell. × 2,000. Note one large pair as observed by Joshi and Rao also.

Joshi and Rao regarding the presence of a progressive difference in the chromosome numbers of genera belonging to the Menispermaceæ, beginning with $n = 12$ in *Tinospora* and passing on through $n = 19$ in *Cocculus* to $n = 26$ in *Menispermum* is without any suggestive relation to Anderson's[3] speculation regarding the origin of the angiosperms, by wide crosses between some of the simpler members of the seven chromosomed and twelve chromosomed gymnosperms, followed by doubling of the chromosomes in the hybrid. Recent studies made in this laboratory by Kumar and Ranadive,[4] on the genus *Anona*, allied to the Menispermaceæ show that $n = 7$ is the haploid number for four species investigated by them. Further, it will be seen that the haploid numbers 12, as well as 7 and multiples of 7 are very frequently met with in Ranunculaceous genera (Gaiser[5]). In *Magnolia denudata*, Andrews[6] has noted $n = 48$, a multiple of 12, and unrelated to $n = 19$, which is found in some other genera of the Magnoliales. If the basic chromosome numbers of primitive dicotyledonous families would give any clue to the origin of the angiosperms, the cytologist can at present go no further than ask whether the angiosperms may not have had a common origin with the gymnosperms in some seven-chromosomed or twelve-chromosomed ancestral type (see Kumar and Ranadive).[4]

A. ABRAHAM.

College of Agriculture,
Poona,
June 11, 1942.

[1] Joshi, A. C., and Rao, B. V. R., *La Cellule*, 1935, **44**, 2, 221.

[2] Lindsay, R. H., *Amer. Jour. Bot.*, 1930, **17**, 2, 152.

[3] Anderson, E., *Nature*, 1934, **133**, 462.

[4] Kumar, L. S. S., and Ranadive, K., *Jour. Bomb. Univ.*, 1942, B. **10**, 3, 1.

[5] Gaiser, L. O., *Bibl. Genetica*, 1930, **6**, 171.

[6] Andrews, F. M., *Beih. Bot. Centralbl.*, 1901, **11**, 134.

PUCCINIA DROOGENSIS BUTLER ON *BERBERIS ARISTATA* D.C.

IN some collections of fungi made at Kodaikanal by the writer in 1940 was a rust on *Berberis aristata* D.C. (*B. tinctora*), which agreed with *Puccinia droogensis* recorded by Butler (1905) in the Nilgiri Hills, S. India. The telia were present in abundance, and associated with them were uredial and æcial pustules. Microscopic examination of the sections of the infected leaves revealed that pycnia æcia and uredia develop from the same infected patch. In another collection made in February 1942, pycnia and æcia were also observed in large numbers along with young uredia. It is manifest that all the spore forms occur on the same host, this being the first report on the occurrence of pycnial and æcial stages for the rust.

Pycnia are distributed on the leaves on slightly swollen patches. The infection spot is pinkish-red in early stages. Pycnia are subepidermal (Fig. 1), amphigenous, minute,

orange-yellow with well-developed ostiolar filaments. They measure up to 120 × 136 μ. Æcia are cupulate (Fig. 5) with incurved margins, and erumpent. Æciospores are yellow, polyhydral, binucleate (Fig. 2), measuring

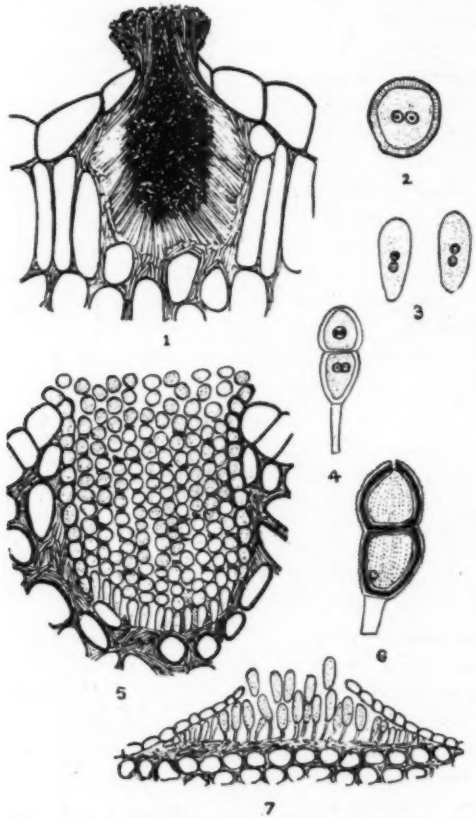


Fig. 1. Subepidermal pycnium × 426·6. Fig. 2. Binucleate æciospore ×533·33. Fig. 3. Urediospores showing verrucose exospore × 426·6. Fig. 4. Young teliospore ×533·33. Fig. 5. Section through an æcium showing chains of spores ×266·33. Fig. 6. Mature teliospore showing three wall layers ×533·33. Fig. 7. Section through an uredium × 106·6.

18-22 × 16·4-18 μ. The germ pores are indistinct and become apparent only at the time of germination. The peridial cells are larger in size, slightly angular, minutely verrucose, measuring 21·8-27 × 16·3-20 μ.

Uredial infections do not cause any hypertrophy. Uredia are subepidermal (Fig. 7), amphigenous, yellow, minute, aparaphysate and pulverulent. The urediospores are stipitate, clavate or ellipsoid (Fig. 3) and minutely verrucose, measuring 16-20 × 27-41 μ.

Telia are purplish-brown and amphigenous. The sori are erumpent and confluent in concentric rings. It was noted that the telia are formed within old uredia. Teliospores are two-celled (Fig. 6), stipitate, rounded at both ends, and constricted in the region of septa. Young teliospores are binucleate (Fig. 4) and the two nuclei fuse forming a syncaryon. There are three wall layers, the outermost being cuticular and covered with minute tubercles. These are arranged in longitudinal rows giving the spores a striate appearance. There is a single distinct germ pore in each cell of the spore, and this feature, in spite of the fact that there are three wall layers, clearly points out that the rust is *Puccinia*, and separates it from *Cumminsiella* recorded on other species of *Berberis* (Arthur, 1933). The teliospores measure 30-44 × 19-23 μ, and germinate within three days when placed in moist chamber.

The rust is an autoecious eu-form. *Æcidium montanum* Butler which is recorded on *Berberis Lycium* Royle, *B. Coriaria* Royle, and *B. aristata* D.C., causes witches brooms and extensive deformations of the host tissue. The æcia of *Puccinia droogensis* on the other hand do not cause such malformation, the sori being distributed on slightly swollen patches. Further the æciospores of *Æcidium montanum* measure 17-35 × 17-29 μ (average 19 × 23 μ), but those of *Puccinia droogensis* 18-22 × 16·4-18 μ. These characters differentiate *Æcidium montanum* from the æcial stage of *Puccinia droogensis*.

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June 5, 1942.

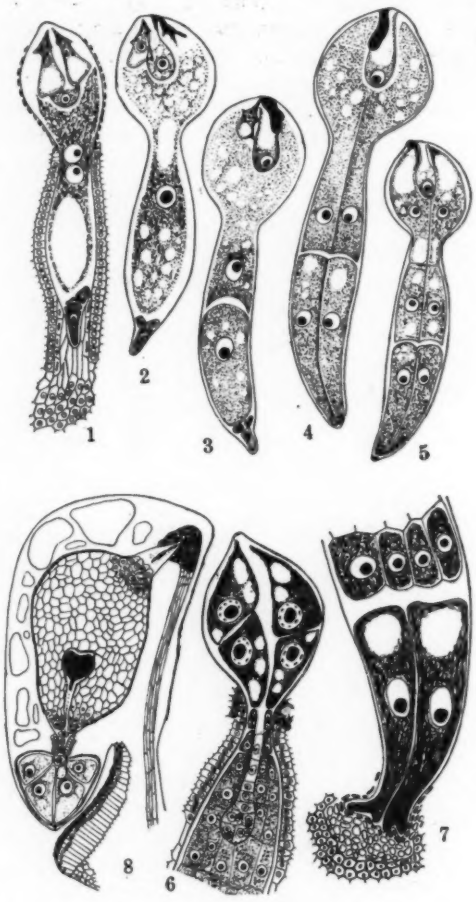
[1] Arthur J. C., *Bull. Torrey Bot. cl.*, 1933, **9**, 475.
[2] Butler, E. J., *Ind. Forester*, 1905, **31**, 670.

ENDOSPERM FORMATION IN *ANISOMELES* SP.

THE present study embodies a short account of the origin and development of endosperm in *Anisomeles malabarica* and *A. indica*. Further work on the embryological and other morphological aspects of these plants is in progress.

The embryo-sac in both species exhibits two distinct regions, *viz.*, a broadened micropylar part containing the egg apparatus and a narrow chalazal part invested by a jacket of integumental nutritive cells. The region between these two parts is constricted, where, the polar nuclei fuse to form the secondary nucleus (Fig. 1).

After fertilization, the primary endosperm nucleus moves to the middle of the chalazal end of the embryo-sac and divides by a transverse wall to form two chambers (Figs. 2 and 3). The nuclei in both the upper and lower chambers now divide by longitudinal walls (Fig. 4). The lower two cells do not divide further but assume the function of an haustorium, and begin to penetrate in the direction of the vascular trace. The two upper cells, on the contrary, divide once more by transverse walls resulting in four cells (Fig. 5). Thus three primary tiers of two cells each are formed in the embryo-sac. The uppermost cells divide once more by transverse walls into four cells which enlarge and organise micropylar haustorial apparatus (Fig. 6). The middle cells, which lie between the two-celled chalazal and four-celled micropylar haustoria, divide further by vertical and transverse walls and give rise to a massive central endosperm tissue in which the embryo becomes embedded ultimately. The nuclei in the micropylar haustorial cells enlarge considerably and show conspicuous nucleoli (Figs. 6 and 7). The chalazal haustorium begins to function earlier than the micropylar haustorium and disorganises after absorbing the nutrition transported by the vascular trace. The micropylar haustorium takes part in the absorption of the disintegrating integumental tissue and continues its function until the embryo has reached considerable size. The passage between the micropylar haustorium and the central endosperm



FIGS. 1-8. *Anisomeles indica*

Fig. 1. Eight-nucleate embryo-sac × 800. Fig. 2. Post-fertilisation embryo-sac showing the prominent primary endosperm nucleus × 800. Fig. 3. Embryo-sac divided into micropylar and chalazal chambers × 800. Fig. 4. Formation of longitudinal walls in the upper and lower chambers of the embryo-sac × 800. Fig. 5. Embryo-sac showing the three primary pairs of endosperm cells ×560. Fig. 6. Micropylar haustorium and embryo × 800. Fig. 7. Chalazal haustorium at an advanced stage × 800. Fig. 8. *A. malabarica*.

A longitudinal section of the ovule showing the micropylar haustorium, endosperm tissue, lacunæ in the integument and the obturator × 160.

tissue is constricted into a narrow isthmus through which nutritive material is transported to the growing embryo by means of conducting cells which are transformed endosperm cells (Fig. 8).

The development of the central endosperm tissue takes place simultaneously with the growth of the haustoria and finally it attains a large size by destroying the surrounding ovular tissue (Fig. 8). In advanced stages, a section of the ovule reveals a large mass of endosperm enclosing the growing embryo and the remnants of the haustoria, both micropylar and chalazal, still persisting.

The pro-embryo descends into the central endosperm tissue by means of its long suspensor and the embryo is initiated in its terminal cell by a vertical wall. The embryo enlarges to such an extent as to displace the endosperm tissue almost completely.

The ovule in both species is characterised by the presence of a massive obturator over the micropyle. The sub-epidermal cells of the obturator become elongated as the development of the embryo progresses (Fig. 8).

In conclusion, I wish to acknowledge my indebtedness to Dr. L. Narayan Rao, Professor of Botany, for his kind guidance.

S. Narasimha Murthy.

Department of Botany,
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Bangalore,
June 6, 1942.

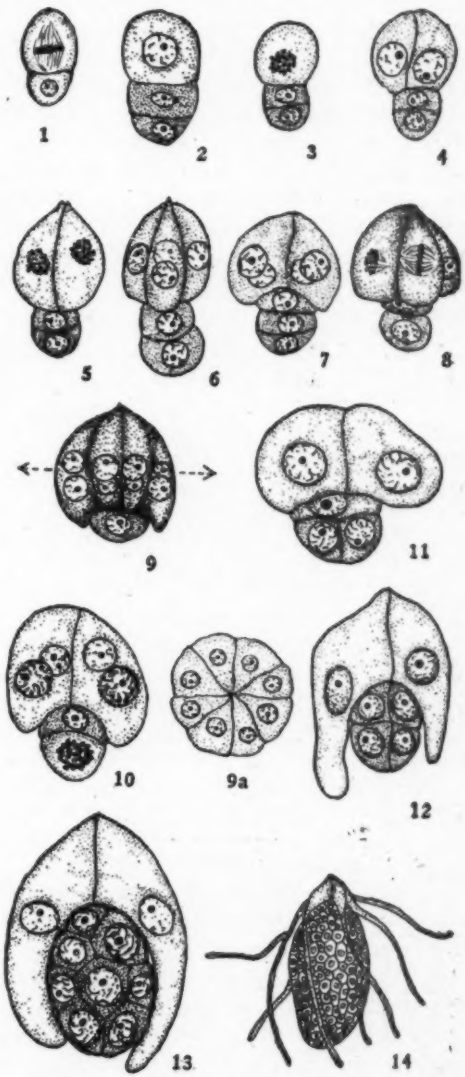
MORPHOLOGICAL STUDIES IN THREE SPECIES OF *VANDA*

Orchids present much morphological variations especially during the post-fertilization development. This note is confined to observations on the following species of *Vanda*:—

V. parviflora Lindl.
V. spathulata Spreng.
V. Roxburghii Br.

Development of the embryo was traced in greater detail in *V. parviflora*, but the course of development appears to be similar in all the three species.

The development of the embryo-sac is of the



Figs. 1 to 13 × 450; Fig. 14 × 80.

Normal-Type, sometimes presenting a tendency towards a reduction in the number of nuclei at the antipodal end of the embryo-sac. Double fertilisation occurs. The primary endosperm

nucleus degenerates sometimes even before a complete fusion of all the three nuclei.

The zygote divides by a transverse wall. The micropylar cell divides first (Fig. 1) giving rise to a pro-embryo of three superposed cells (Fig. 2), characteristic of many Orchids. The uppermost (basal) cell now enlarges and divides by two vertical walls, intersecting at right angles (Figs. 3 to 7) so that a tier of four cells results. Each of these four cells divides by another vertical wall (Fig. 8), ultimately giving rise to eight cells (Figs. 9 and 9*a*). Figure 9*a* represents an optical transverse section of the stage indicated in Fig. 9, at the region of the dotted line.

Subsequent stages show that these eight cells elongate and almost engulf the embryo proper (Figs. 10, 12 and 13). Fig. 14 shows a mature embryo with the surrounding suspensor cells, which dwindle down and wither away at the time of the dispersal of the seed.

Somewhere at the 4-celled stage of the suspensor, the terminal cell of the pro-embryo divides by a longitudinal wall (Figs. 10 and 11); a similar division also takes place in the middle cell of the pro-embryo, resulting in a group of four cells (Fig. 12). The subsequent divisions are irregular and result in a spherical or oval-shaped embryo.

B. G. L. Swamy.

Bangalore,
June 5, 1942.

A PRELIMINARY NOTE ON THE STERILITY IN FLAX (*LINUM USITATISSIMUM*)

Sterility in crop plants is of common occurrence and has been the object of extensive investigation by cytogeneticists. Bateson and Gairdner[1] reported pollen sterility in flax varieties studied by them. In the flax varieties, JLord, Liral purple, Liral monarch and Triumph, planted in the experimental plots of the Department of Agriculture, Bangalore, the writer observed that in many of the apparently ripe capsules only sterile seeds devoid of embryos and abortive ovules being present. A detailed investigation undertaken revealed female sterility which had not been reported so far, on a large scale. Developmental stages of the embryo-sac was traced with a view to find out the exact stage at which degeneration set in.

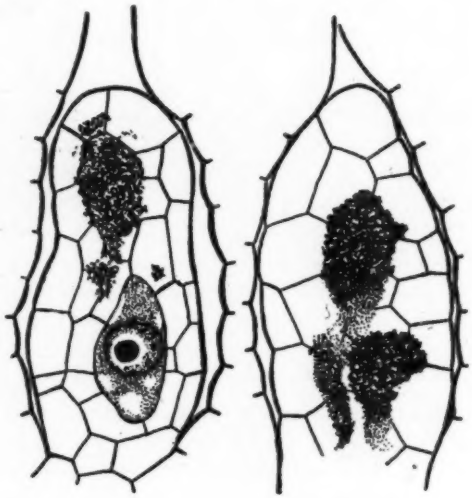


Fig. 1 Fig. 2

1. Section of ovule showing enlargement of the megaspore mother-cell before the usual heterotypic and homeotypic divisions. The degenerated mass seen is the degenerating nucellar cells. × 1520.

2. Degenerated mass of cells in place of a linear row of tetrads. × 1520.

The development of the embryo-sac conforms to the normal type. This feature has already been recorded by Schürhoff[2] for *Linum usitatissimum* and Soueges[3] for *Linum catharticum*. The archesporium is hypodermal in origin and cuts off the parietal cell. Occurrence of multiple archesporium has also been noticed but only one of them develops further. In normal cases the megaspore mother-cell (Fig. 1) undergoes the usual heterotypic and homoetypic divisions to form the linear tetrad of megaspores. The chalazal megaspore enlarges and forms the embryo-sac. In many cases (where there is sterility) the megaspore mother-cell enlarges in size and degenerates without undergoing the heterotypic divisions. In place of a

linear row of tetrads a degenerate mass of cells can be observed (Fig. 2).

Another interesting feature noticed was that in the case of sterile capsules not only the carpellary wall continues to develop to the same size as in the fertile ones but some seeds lacking embryos also develop. Such a feature has been observed in parthenocarpic type of development wherein the carpellary walls continue to grow due to the stimulus of pollen grains which in some instances affect similarly in the development of seeds having no embryos.

In conclusion, the writer wishes to acknowledge his grateful thanks to the Director of Agriculture in Mysore, Bangalore, for giving facilities to work in the Botany Section. He is also indebted to Dr. L. S. Dorasami, Economic Botanist, for valuable guidance and encouragement.

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Botany Section,
Agricultural Department,
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May 6, 1942.

[1] Bateson and Gairdner, *J. Genetics*, 1921, **11**, 269–79.
[2] Schürhoff, *Jahrb. f. wiss. Bot.*, 1924, **63**, 707–59.
[3] Soueges, R., *C. R. ac. Paris*, 1924, **178**, 1307–10.

THE INFLUENCE OF PACKING ON THE MOVEMENT OF MOISTURE THROUGH THE SOIL

AIR-DRIED soil sieved through a 0·5 mm. sieve was packed in glass tubes of internal diameter 1·3 cm. A given mass of soil can be packed *loosely* without any obvious air gaps so as to occupy a certain *maximum* length in the glass tube. Later, when the glass tube is dropped from a height of 6" repeatedly, the length of the soil column gradually decreases and finally it attains a *minimum* value which represents the *closest* packing possible by this process. Table I shows the volume (V in c.c.) occupied by 4 oz. of Poona (black cotton) soil at different stages of packing. The contraction in volume at any stage is expressed as a percentage of the maximum contraction possible by this method and is called the *percentage of packing*.

A rectangular metallic reservoir (Fig. 1) with 4 side openings on each of two opposite sides at a level of about 1½ inches above the bottom and containing water up to a constant level was used to feed water into 8 (replicates)

TABLE I

V. in c.c.*	99·30	97·05	94·30	91·80	89·30	87·30	84·30
Difference†	0·00	2·25	5·00	7·50	10·00	12·00	15·00
% of packing‡	0·0	15·0	33·3	50·0	66·6	80·00	100·0

* Volume occupied by 4 oz. of Poona soil in c.c.
† Difference in volume from that at minimum packing.
‡ % of packing.

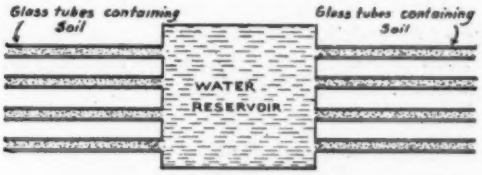

FIG. 1
Plan of apparatus for measuring movement of water through horizontal soil columns

tubes containing soil at a particular percentage of packing. The tubes were all kept horizontal so that the force drawing water from the reservoir was practically due to the capillary pull of the soil column, the constant head of water above the axis of the tube maintained in the reservoir being only 3 cm. Measurements of the lengths of the soil columns wetted by water were made at suitable time intervals. The experiment was repeated for each degree of packing. The mean lengths (the coefficients of variability were of the order of 5 per cent.) of the wetted soil columns have been plotted against the percentage of packing in Fig. 2. Each curve refers to a particular time interval after the commencement of the experiment. It is very interesting to note that the points referring to any particular time interval practically fall on a straight line. It is also of interest to note that all the straight lines meet the horizontal axis at the same point, *viz.*, 166 per cent., of packing, indicating that, if the soil had been packed by some other method by 66

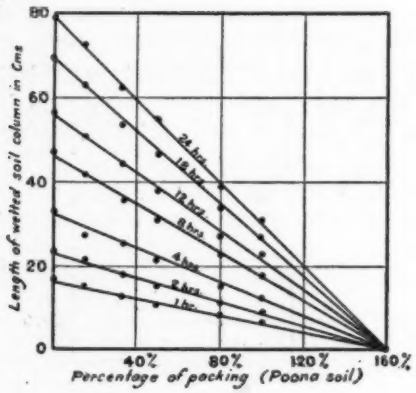

FIG. 2

per cent. more than was possible by the dropping method, a stage would have been reached when water *would not pass through the medium*. We may call this the "impervious" point.

Table II gives the volumes occupied by 4 oz. of Bangalore soil at different stages of packing.

TABLE II

V. in c.c.*	98·40	96·00	93·15	90·40	87·70	85·60	82·40
Difference†	0·00	2·40	5·35	8·00	10·70	12·80	16·00
% of packing‡	0·0	15·0	33·3	50·0	66·6	80·0	100·0

* Volume occupied by 4 oz. of Bangalore soil in c.c.

† Difference in volume from that at minimum packing.

‡ % of packing.

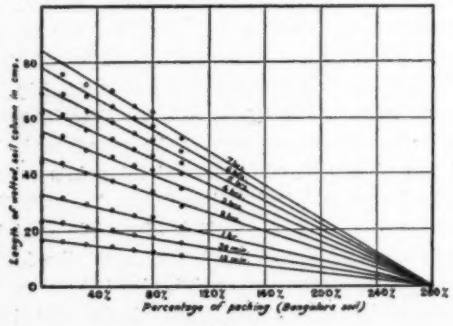

FIG. 3

The measurements of the lengths of wetted soil in tubes of Bangalore soil at different stages of packing were made in 8 replications as before. Fig. 3 shows the relation between the mean length of wetted soil column and the degrees of packing. Here also the relationship is linear and the straight lines all meet the horizontal axis at the 280 per cent. point. Thus the further packing necessary to reach the "impervious" point in this case is 180 per cent. more than the maximum packing actually achieved by the dropping method.

The "impervious" point appears to be a characteristic property of a soil and the investigation of other soils by this method is being taken up.

The author's thanks are due to Dr. L. A. Ramdas for suggesting the present investigation and for guidance.

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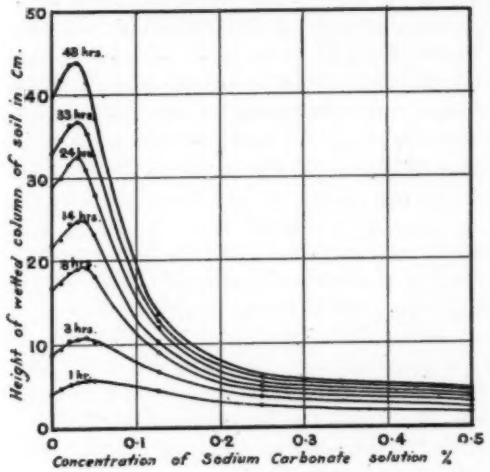
Meteorological Office,
Poona,
June 17, 1942.

THE EFFECT OF CONCENTRATION ON THE CAPILLARY MOVEMENT OF SOME SALT SOLUTIONS THROUGH THE BLACK COTTON SOIL

IN two papers due to appear shortly in the *Proceedings of the Indian Academy of Sciences*, Ramdas and Mallik have discussed the results of a series of experiments on some properties of the black cotton soil. It was found that salts, the solutions of which move less freely through the soil than pure water, caused *swelling* of the layer of colloidal material with which the particles of black cotton soil are coated.

The purpose of this note is to show the effect of increasing the concentration of the salt solution on the rate of its upward movement through vertical columns of the soil packed in glass tubes. Four replications of soil columns were used for each concentration starting with 0 per cent. (pure water) and ending with the

highest concentration which it was necessary to use in the experiments. We may describe here the results of the experiment using sodium carbonate. The figure shows the variation of the length (in cm.) of the soil



column visibly wetted by the solution, as a result of capillary ascent, with the concentration of the solution. Each curve in the figure refers to a particular time interval after the commencement of the experiment. It is very interesting to note that, as the concentration is increased from 0 per cent. (water) to about 0·03 per cent., there is an *increase* in the upward movement and that the well-known impermeability of the soil in the presence of sodium carbonate begins only when the concentration is increased beyond the above optimum value. The permeability of the soil decreases very rapidly as the concentration increases from 0·03 per cent. to 0·1 per cent., the decrease with further increase of concentration being less conspicuous. At a concentration of 1·0 per cent. the solution hardly shows any upward movement through the soil even after the lapse of several weeks. It may be remarked that the increase in the upward movement with traces of sodium carbonate is probably due to the slight constriction of the capillaries between soil particles due to incipient swelling of their colloidal coatings and the consequent increase in the upward pull. Further swelling causes choking of the capillary pores and consequent impermeability. Very similar results have been obtained with oxalic acid, sodium oxalate, lithium carbonate and the experiments are being continued with other salts.

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A. K. Mallik.
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Agricultural Meteorology Section,
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Poona,
June 10, 1942.

FUNGUS DISEASE OF GOURAMI (*OSPHROMENUS GORAMY* LACEPEDE)* IN A POND AT MADRAS

A pond in the Government House Gardens, Guindy (Madras), was stocked with 30 gourami fingerlings (*Osphromenus goramy*) ranging in size from 3"-7" on 2nd April 1940, along with 100 Pearl-spot (*Etroplus suratensis*). In August 1941 the tank shrank to $^1/_5$th of its size, the depth of the water went down to 3' 7" at the deepest part and the water was thick and muddy. A trial netting was made and 4 gourami, 10"-11" long (2 males and 2 females), 13 pearl-spot, 2½"-5½" long and 1 climbing-Perch (*Anabas scandens*) were caught. Of the 4 specimens of gourami, 3 exhibited red patches on their sides.

On 17-9-1941 three hauls brought twenty-six gourami, one climbing-perch and one pond-tortoise: the latter two being predaceous, were removed. The sizes of the 26 fish ranged from 7"-12", the average being 9½" in length. All of them had fungus patches and were treated with 3 per cent. salt solution for a minute and released. As the attack of the fish by the fungus was common and persisting, it was found necessary to repeat the treatment.

* With the kind permission of the Director of Industries and Commerce, Madras.

On 1-10-1941 a specimen of gourami, measuring 7½" in length, was taken to the laboratory for observation and treatment, as the fishes in the pond still had the attack. There were three reddish patches on the left side of the body, two in the middle and one one inch from the eye, dorsally and five patches on the right side, one at the base of the pectoral fin, two in the middle and two at the base of the caudal fin. The right eye was injured, bulging, opaque and dark brown in colour and the left eye, though not injured, was dark brown in colour. On examination, the red patches on the body showed the presence of *Saprolegina sp.*, a fungus which commonly attacks freshwater fish. This fish was kept in an aquarium in clear water after giving a saline bath. The water was changed twice a day and the fish fed regularly with leaves of water-lilies, vallisneria, boiled rice, and oil-cake. The reddish patches of fungus turned pale; the eyes became normal; the pale white colour of the fish changed to brown with a rosy hue. The fungus patches disappeared in about a week. The fungus though not harmful by itself, enables pernicious bacteria and other parasites to get a hold on the surface of the skin which destroy the tissues and cause great havoc to fish-life.

This fungus attack may be attributed to (1) overcrowding of the pond with fish, (2) pollution caused by decaying organic matter, (3) injuries caused in a limited area by enemies, such as the pond-tortoise and climbing-perch and (4) lipoid-disease caused by malnutrition. The above factors were noticed in the present case, except the lipoid-disease for which no examination was made. The pond in April 1941 had shrunk to $^1/_5$th of the original size, rendering the water area less roomy for the fish. The water was muddy and all the weeds, water-lilies, etc., had shrivelled up in the hot weather, thus depriving the fish of their chief food.

As it was also suspected that the disease might be due to some chemical factor, both samples of water—one of the pond in Guindy and the other in which the fish was kept for observation—were analysed,† for chlorine content, hydrogen-ion concentration and oxygen content, etc. The former differed from the latter in having a low alkalinity to methyl orange (2·4 per 100,000 as against 9·5 of the other), low pH (7·1 per 100,000 as against 7·6), a slightly higher oxygen content (0·171 per 100,000 to 0·158) and a less amount of chlorine (0·7 per 100,000 as against 4·6). In spite of the lesser percentage of oxygen and the higher amount of chlorine, the disease has been cured in the clear water in which the fish was under observation.

Mud in suspension chokes the gills of fish and renders respiration difficult with the result that the general conditions and health of the fish suffer deterioration. Besides, overcrowding caused by reduced environmental area is generally responsible for loss of health and condition of fish. The presence of enemies like the pond-tortoise and the climbing-perch had caused abrasions and loss of scales and injury to the fish in this instance. Such injured spots on the fish form the foci for the attack and spread of fungus diseases. The spread of the disease must have also been accelerated by the high temperature of the season and want of sufficient food.

K. CHIDAMBARAM.

Madras Fisheries Service,
April 3, 1942.

† The water samples were analysed at the King Institute, Guindy, Madras.

[1] Davis, H. S., "Care and Diseases of Trout", *U. S. Bureau of Fish, Inv. Rept.*, 1937, No. 35.
[2] Malik, G. M., *Bom. Nat. Hist. Soc.*, 1939, **41**, No. 2.
[3] Mather, F., Pleha, M., *Praktikum Der. Fishkrankheiten*, 1909.

THE MANUFACTURE OF GLANDULAR PRODUCTS IN INDIA

THE note on the above subject by Prof. B. B. Dey[1] and its subsequent rejoinder by Dr. B. Mukerji[2] seem to be of considerable interest at this particular juncture. True it is that many things can be produced in India from the Indian raw materials; but in most discussions, symposia or in writings only one side of

the shield is being scrutinised. Prof. Dey points out that three and half lakhs of cattle are being slaughtered annually in the various cities of the country and these may be easily utilised for the manufacture of glandular products like adrenaline, pituitary extract, liver principles, etc., etc. It may be noted, however, that these animals too would not offer more than 0·7 million suprarenal glands which on no account would afford more than 100 ounces of adrenaline powder. Further the type of animals that are generally being slaughtered, would not offer the maximum amount of physiological principles[3] in question. Even the above maximum amount would not be sufficient for meeting the market already established for Liquor Adrenalin Hydrochloride of the manufacturing concern from which this note is being written. Similar question arises on the availability of sufficient amount of pituitary (posteriar lobe) powder within the country. Liquid extract of liver is another product which can, of course, be easily prepared and in practice this is being largely produced too. The difficulty, however, again arises with the isolation and standardisation of an active liver principle that might be suitable for parenteral administration in Indian cases. Extensive physiological and clinical investigations would be necessary for finding out the necessity or utility of one or other liver principle in this tropical country. Here bullocks, oxen and cows are used for cultivation work. The children of the soil are mostly poor and vegetarian, or, at least not beef eating. Thus the social, geographical and climatic conditions prevailing act as a bar in the progress of large-scale manufacture of glandular products within the country. Many products like adrenaline, testosterone, desoxy corticosterone, synthetic œstrone-like substances of course are now being produced in other countries in artificial way; but their successful productions in India depend on various other factors which are well known to economic industrialists and/or scientific politicians.

As has already been mentioned by Dr. Mukerji certain Indian commercial concerns are producing medicament of requisite standard from the materials that are already available in India. Unfortunately most of our scientists not in touch with Indian industrial concerns are unaware of this fact. It may, however, be stressed here that an all-out drive and concerted efforts of the various scientists working in the different and divergent research institutions and industrial concerns of the country would have helped much in the production of still better, more and newer products. The spirit of such a concerted action is lacking and the existing firms apart from many other trade difficulties even suffer for want of facilities for clinical trials of their finished products in the authorised hospitals of the country.

U. P. Basu.

Bengal Immunity Research Laboratory,
Calcutta,
June 12, 1942.

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[1] This Journal, 1942, **11**, 110.
[2] *Ibid.*, p. 198.
[3] Basu, Bose and Das Gupta, *Indian Med. Gazette*, 1940, **75**, 215.

FATTY OIL FROM THE FRUIT OF *MARTYNIA DIANDRA* (N.O. *PEDALIACEAE*)

The fat from the dried fruit of *Martynia Diandra* (Marathi: *Vinchu*; English: *Devil's Claw*; Hindi: *Bichu*) collected from the neighbourhood of Kolhapur, has been analysed and the results given below. The fat was extracted with carbon tetrachloride in a soxhlet.

Yield—20 per cent. (on the weight of the dried fruit).
Colour—Orange.
Smell—Nothing characteristic.
Specific gravity at 23° C.—0·9528.
Refractive index at 23° C.—1·4720.
Acid number—15·42.
Saponification value—195·3.
Iodine value—75·62.
Reichert-Meissel value—3·877.
Polenske number—0·7825.
Acetyl value—10·79.
Unsaponifiable matter—0·86 per cent.

Rajaram College, Kolhapur, *May* 14, 1942.
S. V. Shah.
J. W. Airan.
A. V. Rege.

REVIEWS

Economic Control of Iron and Steel Works. By F. L. Meyenberg; with a Foreword by Sir William Larke. (Chapman & Hall Ltd., London), 1942. Pp. xx + 332. Price 25*s*.

The author of the book is an acknowledged expert in the subject-matter treated and is now living in England as a naturalised British subject. He was engaged for more than a dozen years, first in the German iron and steel industry and then as a Professor of Industrial Administration at a technical university, when he frequently participated in the meetings of the Committee of Works-Economics of the Verein Deutscher Eisenhuttenleute. He was employed by the British Iron & Steel Federation at the time when the "Uniform Costs System" was being compiled, and has been working in the British iron and steel industry for nearly seven years.

The purpose of the book as stated by the author is to discuss the individual parts of economic control and their connections with each other. Only the point of view of considering economic control as an inseparable whole of technical, commercial, administrative and psychological questions can produce the favourable result, which should reasonably be expected from the necessary clerical apparatus. The book deals with these problems from the point of view of the iron and steel industry, but the fundamental explanation can be considered as valid for industrial works generally.

The book describes in five parts the whole sphere of economic control:—accountancy proper and its results, the balance sheet and profit and loss account; works accounts, *i.e.*, costing systems in the individual departments of a large iron and steel works; job accounts—general equations of costs, production and sales statements; standard costs—their derivation and application in budgeting and estimating; and finally, the organization of economic control in which the author indicates proposals for improvement based on his experience, and logical conclusions.

The merits of the work have been fully dealt with in the Foreword by Sir William Larke, K.B.E., Director of the British Iron and Steel Federation. Sir William supports the author's view that the relationship between the accounting, commercial and production departments of works should be that of active and understanding co-operation. It is suggested by Sir William that this co-operation will undoubtedly be stimulated by a study of this book and that all those already in or aspiring to executive positions in the industry, whether technical, productive, commercial or financial, should carefully consider this book.

In India, the book ought to be welcomed by not only those who are concerned with the iron and steel industry, but by all who have anything to do in the management and planning of industrial works in general or are going to take part in the shaping of India's industrial future.

J. S. VATCHAGANDHY.

Science and Everyday Life.—By J. B. S. Haldane, F.R.S. (Pelican Books, Penguin Books Co., London and U.S.A.), 1941. Pp. 192.

This is an age when science has been continually influencing and dominating every aspect of human life and culture. It is, therefore, essential that the ordinary man and woman should not only try and understand the achievements of science but also realise their impact on his life and thought. Gifted thinkers like Professor Haldane have taken upon themselves the task of bringing this scientific knowledge to the door of the common man through the hospitality of the columns of the "*Daily Worker*".

The enterprising publishers of the widely appreciated series of Pelican books, have brought together some seventy of these articles as a compact and inexpensive edition, which is prefaced by Professor Haldane himself. The author has dealt in simple and clear language with a great variety of topics—meals, heredity, mathematics and physics, science and society, etc. This series of articles is all the more interesting because of the circumstance that Professor Haldane has happily mixed his own pet Marxist political philosophy with the facts of science. This is a collection which will be gratefully received by the common man

and constitute a guide to those who aspire to render science intelligible to the general public. V. S. G.

Animal Life. By J. R. Bhatt, Moratu Vidyalaya, Moratuwa, Ceylon. (Published by the author), 1941. Pp. iii + 253. Rs. 3.

This book has particular reference to animal life in Ceylon and the author who appears to be a teacher of Biology in that country has evidently an abundant interest in and intimate knowledge of the fauna of Ceylon and he has dealt with the subject in a manner intelligible to both the layman and the biologist. Everywhere the economic aspect of the animal life of Ceylon has been emphasised and the book gives a popular account of the bearing of the fauna of the island on human life and activity. The arrangement of the chapters does not indicate the sequence of zoological evolution but in beginning his book with an account of insects the author evidently has in his mind the great part they play in human affairs and the immense importance they have assumed in the lives of men. Ceylon, like India, is an agricultural country and insects of particular interest to the agriculturist have been given special treatment.

Generally speaking, the faunal life of Ceylon is not very different from that of South India and the educative value of the book is therefore not restricted to the island of Ceylon with which it mainly deals. The insects the author has described, the earthworm and the leech, the frog, the fish and the fowl, and the various mammals the author deals with are also denizens of peninsular India and *Animal Life* is therefore of as much value to students and teachers in South India as it is to those in Ceylon. The book is evidently very popular in Ceylon and there is every reason to believe that it will be just as greatly in demand in India also. B. R. S.

The Eternal Quest: Studies in Philosophy. By M. A. Venkata Rao. (Hosali Press, Bangalore), 1942. Pp. 254. Rs. 5 or 7*s.* 6*d.*

Dedicated quite appropriately to the "Spirit of Philosophy" and animated by the "motive" that "a variety of concrete Idealism able to meet Realism at its 'toughest' with a determination to do justice to every phase of problems, with a willingness to follow the method of analysis so far it can be followed with meaning (p. iii—Preface) Prof. Venkata Rao's book *Studies in Philosophy*, is sure to remind his readers of the sternly intellectualistic attitude of Hegel who is said to have gone on working with his speculative effort within ear-shot of a fierce fight and roar of cannons. "Philosophical studies" in 1942, the year of grace, which finds India threatened by unscrupulous aggressors would easily demonstrate that well-directed Indian cultural endeavour is always devoted to the Eternal Quest. In the publication under notice, Prof. Venkata Rao has brought together *eleven* essays many of which had already appeared in periodicals. Each essay is independent in itself, dealing with a specific topic or problem. Though throughout comparative study of Indian and European doctrines is attempted, three studies distinctively deal with "Karma and Kant's Postulates of Morality", "Christian Immortality and Hindu Re-incarnation", and "Bradley and Bhagavad-Gita".

In judging a collection of studies or essays on different problems of philosophy, a reviewer is sure to find himself at a disadvantage as the publication is not devoted to a development of a single theme or thesis. Each essay or study will have to be thus judged on its merits as an independent unit. I shall consider one or two as within the limits of this notice, it would be impossible to cover all.

In his study on "The Notion of Difference in Dvaita", Prof. Venkata Rao examines the criticisms urged against the concept of difference by adherents or advocates of Monism or Absolutism (Advaita) and comes to the conclusion that "Both are systems of idealism, for both uphold an infinite consciousness, but Advaita is pure idealism denying all otherness whereas Dvaita is concrete idealism accepting otherness as essential to the nature of reality" (p. 145). I am afraid the conclusion does not describe Dvaita as it is. Upholding of an infinite consciousness (spelt with small "i" and "c" by the professor) does not necessarily make or convert a system into Idealism. On the contrary, the issue both in Indian and European systems is between Idealism and Realism. Quite apart from consciousness, finite and infinite, Realism admits objects

and entities which are non-mental, non-ideational though these enter into the relation known as knowledge. Thus, the description of Dvaita as "concrete idealism" is a distortion. Dvaita is Realism. (In Indian philosophy *Tattva-vada* is contrasted with *Maya-vada*—i.e., Realism is contrasted with Illusionism.) Dvaita is emphatically *not* the idealism of Spinoza, Berkeley, Bradley, Kant and others. It is not idealism at all. It must be observed that idealistic systems which make or enter into cheap compromises with Realism, and similarly, Realistic systems which coquette with Idealism "pure" or "concrete" must both be banned from decent metaphysical company. And then, "concrete idealism" is better contrasted with "abstract idealism". A system can both be "pure" and "concrete". There is no antagonism between the two. All attempts wherever and by whomsoever made to bring Dvaita under "idealism" must fail. Dvaita is Realism. Secondly, Idealism is not the only fashionable or rational world-view.

Again, Prof. Venkata Rao has drawn but a doubtful parallelism between Bradley's "My station and its duties" and the Gita ideal of "Svadharma". If, for instance, one, be he a peon or a prime-minister, does his duty and draws his salary would that be the "path of realisation"? (p. 221). Bradley does not touch even the remotest fringe of Karma-Sanyasa (Sankara) and Karma-Yoga (Ramanuja and Madhva) interpretations of the Gita. I am afraid such doubtful parallelisms may not promote correct and sympathetic understanding between the East and the West for the securing of which presumably they are drawn.

These comments, I must add in conclusion, will not touch the general excellence of the treatment of the different topics by Prof. Venkata Rao. After completing a study of the volume, readers will get just a picture of disjointed snap-shots of the problems of philosophy. "One is surprised", writes Prof. Venkata Rao, "at the wealth of philosophical material waiting to be interpreted" (Preface). He has ample opportunities for study and research and I am sure at the earliest possible one, he will concentrate his attention on some one work "waiting to be interpreted" and develop his thesis in an independent unified volume.

R. NAGA RAJA SARMA.

MILK IN RELATION TO HEALTH

MILK provides the closest approach to an ideal diet and it has a special value in the Indian dietary where it forms the only source of first class animal proteins. From the nutritional standpoint a consumption of 1½ lbs. of milk per day may be considered absolutely necessary for an adult. Repeated surveys that have been carried out on this subject in India have, however, shown that the consumption is far below this optimum. The latest survey of the Agricultural Marketing in India in their report on "Marketing of Milk in India and Burma"* shows an average *per capita* consumption of milk and milk products at 7 ozs. of milk per day. Milk from Indian animals is no doubt very rich in fat (average 6 per cent.) compared to that produced in other countries (average 3·5 per cent.) and if milk consumed in India is toned down to this lower fat percentage the *per capita* intake of milk would be increased to 10·5 ozs. Of course, it is a debatable point whether so much importance could be attached to fat alone. The protein percentage of milk of Indian breeds of cattle is no doubt slightly higher than in milk of Western breeds but this is nothing compared to the very high fat percentage in the former and the mineral salts are by no means higher. Hence this dilution cannot be justified from the nutritional point of view. Even considering this higher figure as correct there is still a very great and urgent need for increasing the production and consumption of milk in this country.

Fortunately the value of milk and milk products for human nutrition is well known to consumers in India and this has been preached by her sages from most remote times. This was not so in many other countries but once the science had proved the value of milk, people were quick to take advantage of these new discoveries and today India has much to learn from their example. The first essential for milk production is a well balanced food for the animals. India has about a third of the

* *Report on the Marketing of Milk in India and Burma* (Manager of Publications, Delhi), 1941, pp. iii + 54. Price As. 8 or 9 *d*.

world's cattle population but many of these animals have to live on straw. The tendency to breed animals without any planning further makes this shortage acute. It is thus quite essential to have a proper record of the performance of each animal with the object of keeping only the profitable ones and weeding out those that are unprofitable. In India the number of milch animals whose record is maintained comes to only about 0·03 per cent. This unthrifty character of indigenous cattle is further illustrated by the figure for the milk production quoted in the above report. The average annual milk yield for cows varies from 65 lbs. to 1,825 lbs. Buffalo in comparison, is a better milk producer but the controversy as to whether India should get all milk only from cows or buffaloes is premature. All these resources must be harnessed for to-day's needs. For the development of dairy industry on proper lines it is quite essential that breeding should be done on scientific basis and a record of every animal maintained. This will of course be beyond the economical means of individual farmers but much can be achieved by village co-operative organisations.

The greatest stimulant to milk production is to increase the demand for milk, and under Indian conditions the attention must be focussed on the rural areas. One of the striking points brought out by the Agricultural Marketing Report is that even in rural areas of important dairy districts about 20 per cent. of the families, including children, do not consume any milk or milk products. When there is a local excess of milk it is usually converted into ghee. One of the chief attractions for the villager to make ghee is no doubt the ready cash it brings. But this is rather an uneconomic method of disposing off milk as the price realised by sale of ghee is much less and also because quite a large amount of the "lassi" produced as a bye-product is, contrary to the general belief, wasted.

The milk problem in the urban centres of India is also acute. The most undesirable aspect of this problem is that about 60–70 per cent. of the milk requirement is supplied by the animals housed within the municipal limits. The cost of maintenance in such centres is necessarily very high and due to economic reasons there is any amount of cruelty practised on dumb animals. These animals are slaughtered as soon as they go dry and this is a great drain on the cattle wealth of the country, as usually the animals brought to the cities are the best of their type. This and restricted transport facilities make the price at which milk is sold in urban centres very high in spite of the fact that milk is delivered in a crude state, no processing or bottling is done and also the chemical and hygienic quality of the samples is doubtful. Adulteration is practised on an extensive scale. The report has suggested a tentative scheme for the distribution of milk in the urban centres which is worth considering as need for some such co-operative organisation is badly felt. The suggestion made in the report about "toning" of milk to a standard butterfat percentage is also very valuable. It is estimated that in urban areas about 46 lakh maunds of skimmed milk is produced as a bye-product of creamery butter industry and if this can be used to mix with our fat rich milk, the same quantity of milk can be made to go round further.

Another aspect of milk production to which so far little attention has been paid is its degree of cleanliness. Unfortunately it is very difficult to distinguish by ordinary human senses good from safe milk. The report gives some very enlightening illustrations under which milk is to-day produced and sold in the urban centres. They need wider publicity within this country to arouse the consumers from their apathy. Unless there is a genuine demand and appreciation for clean milk, producers can hardly be expected to pay much heed to the conditions of production. On the other hand, any indirect method of making bad milk good is sure to be expensive to the country in the long run. The universal practice is to boil the milk and though the extent of boiling differs in different parts of the country, on an average it can be estimated that at least 5 per cent. of all the valuable constituents are lost. Another common procedure is to keep the milk simmering all throughout the day in confectioners' shops. Here the loss of nutrients will no doubt be much greater.

Production of milk and particularly of clean milk are closely bound up with the market price. In almost all the countries where dairy industry has been organised the control of milk prices has been the first and essential step. The State also gives its full share in the organisation of the dairy industry. Without this help the state of things in these countries would not have

been much different from what prevails in India to-day. At present it is difficult to estimate whether the Indian producer is working at a profit or loss but from the few data that are available and their comparison with the cost as estimated on some of the systematically run farms, it is clear that the producer has to be satisfied if he does not incur any loss. For example, it has been shown that there was a steady fall in the price of wholesale milk during the last ten years. An industry that rests on such slender basis cannot progress. A thorough reorganisation is necessary. This need not necessarily mean an increase in the price of milk from what prevails to-day. It is estimated that the cost of running the Milk Marketing Scheme in England comes to less than 1 per cent. of the value of milk sold. This cost is insignificant considering the great boon it has proved to the community. Similar results could be achieved in India too.

In India dairying is pursued largely as a side line and the whole industry, though colossal in its magnitude, has an individualistic outlook. Production of milk and rearing of good milch animals are, on the other hand, quite intricate processes. Hence a new orientation in the outlook is essential. For progress, co-operation is necessary and for bettering the condition of the dairy industry the absence of village co-operative organisations is urgently felt. It is such co-operative societies alone that can decide the breeding policy, create means to put it in practice, the price at which every villager will sell his milk and milk products, the quality of food that will be grown, the quantity of milk every child in the village will receive and so on. These village centres may in turn be linked with consumer's co-operative unions in the urban centres and thus a countrywide organisation set up. When the rural areas are organised the urban problem will be solved automatically or at least without much difficulty. The object of such co-operative centres should not merely be more profit for its members. Side by side it must increase the consuming capacity of the members and by better education help them to select or produce right type of food.

The problem of nutrition is thus closely linked up with better organisation of the dairy industry of the country, for, better diet means always more milk. In the past few years the milk problem in India has been widely discussed and learned theses produced. It is now time to translate these suggestions into practice.

N. N. DASTUR.

CENTENARIES

Sharp, Abraham (1651–1742)

ABRAHAM SHARP, an English mathematician, was born in Bradford in 1651. After apprenticing to a merchant at Manchester, he moved to Liverpool and devoted himself to mathematics. From 1684 to 1690 he was employed under Flamsteed in the newly founded observatory at Greenwhich and in 1688 he graduated with extraordinary accuracy a mural circle for that observatory.

Sharp calculated π to 72 places and the logarithms of all numbers from 1 to 100 and of all primes upto 1100 to 61 places.

Sharp died near Bradford, 18 July 1742.

Dallinger, William Henry (1842–1909)

WILLIAM HENRY DALLINGER, an English biologist, was a Wesleyan minister by profession. From 1870 to 1880 he pursued microscopic researches into minute pathogenic organisms. This gave him a mastery of microscopical technique and earned him reputation for his classical investigations into the life-history of some micro-organisms, particularly flagellates. In one instance he had an individual monad under observation continuously for thirty-two hours. Incidentally he threw much light on the then controverted question of abiogenesis.

One of his investigations proved the futility of the ordinary precaution of boiling for sterilising. For it proved that though the temperature of boiling water was fatal to monads in an active state, their spores could stand a temperature upto 300°.

Dallinger died at Lee, Kent, 7 November 1909.

S. R. RANGANATHAN.
University Library,
Madras.

SCIENCE NOTES AND NEWS

Studies on the Photo-Chemical Activity of Mixtures of Vanadic Acid and Tartaric Acid.—The study of the relationship between pH and (1) optical rotation, (2) light absorption and (3) dark reaction, with mixtures of vanadic acid and *d*- or *l*-tartaric acid at $pH < 4{\cdot}0$ has shown the existence of negatively charged colloidal micelles of poly-vanadic acid-tartaric acid. These micelles exist in equilibrium with the hydrogen ions in the solution:

$$[x.VO_3^-, y.\overset{A}{H_2}T, Z.H^+] \rightleftarrows [H^+]$$

$$+[x.VO_3^-, y.\overset{B}{H_2}T, (Z-1)H^+] \text{ where T = Tartrate ion.}$$

The optical rotation and light absorption are due to the micelle B, whereas the micelle A is responsible for the dark reaction. The velocity of the oxidation of recemic-tartaric acid by vanadic acid has a higher value than that for *d*-, *l*- or *dl*-acids. This important observation lends support to the view of Cotton that a distinction must be made between the solution of a racemate and a simple mixture which is inactive by external compensation.

The photo-reduction of mixtures of vanadic acid and tartaric acid has been studied in the visible and ultraviolet regions at $pH > 4{\cdot}0$ where equimolecular complex ions of the type ($VO^{--}.HT^-$) appear to exist in solution. Einstein's law of photo-chemical equivalence holds good and a mechanism has been postulated for the photo-process.

The investigation of the influence of *d*- and *l*- circularly polarised light on some photo-chemical reactions involving circularly dichroic systems has shown that, where the anisotropy factor *g* is positive, the velocity of the reaction in *l*-light is greater than that in *d*-light; the reverse is the case when *g* is negative. This is observed in the photo-oxidation in *d*- and *l*-light of *d*- and *l*-tartaric acid by persulphate, using as catalyst circularly dichroic colloidal systems containing poly-vanadous acid. The above reaction with racemic acid results in the production of optical activity. This is an approach towards a complete 'asymmetric synthesis', resolution being effected purely by the agency of light.

Vanadic acid sol. exhibits circular dichroism in the visible region on exposure to circularly polarised light. The photo-reduction of the dichroic sol. by tartaric acid gives differences in reaction velocity with *d*- and *l*-light. It has also been found that even when the vanadic acid-tartaric acid mixture is not initially dichroic, exposure to *d*- and *l*-light results in induced dichroism in the mixture and also in differences in the velocity of the reaction. Circular dichroism is induced in reduced vanadic acid sol. also on exposure to *d*- and *l*-light independent of the nature of the reductant used for the reduction of the sol.

It appears that in the case of vanadic acid sol. as well as of reduced sol., circularly polarised light exerts a directive influence during the process of formation of micro-crystalline sol. particles and causes a transition from the isotropic to the anisotropic lattice structure. This anisotropy manifests itself as circular dichroism and as a differential velocity effect in photo-chemical reactions taking place in circularly polarised light. T. L. R.

Blood Groups in India.—Discussing the blood group data of twelve aboriginal tribes of India Eileen W. F. Macfarlane and S. S. Sarkar (*American Journal of Physical Anthropology*, 1941, 38, 4) consider that serologically the aboriginal tribes should be regarded as having two broad divisions, "one having the physical characters of the Paniyans or Maler with a low content of B and the other having the physical characters of the Oraons having a low content of A and more B". The Paniyans, Kanikkars and Chenchus of S. India have close relationship in blood groups to the Maler of Bihar, all the four being Dravidian-speaking tribes. Though the Malers and Oraons are neighbours, their blood groups are quite dissimilar. The Bhils and Korkus of Central Provinces have like the Oraons a high percentage of B. "There is in general an increase in the frequencies of genes A and B from South Northward, and in groups B and AB from East to West across Central India". The authors suggest that the Mundari-speaking peoples possibly entered India later.

Nutritional Experiments with Chickens.—As a result of a series of experiments for the investigation of growth-promoting supplements to the basal diet of chicks consisting of locally available cereals, green food and calcium in the form of crushed limestone, Macdonald (*Ind. J. Vet. Sci. & Animal Husbandry*, 1941, 11) has shown that separated milk during the first 6 weeks and separated milk and water from 6 weeks onwards as supplement are essential to ensure proper growth, health and efficiency of the chicks. Where milk is not available or is too costly, soya bean meal and silt with cereals are recommended as the next best. S. D. A.

Goat Spleen Tissue Vaccine as an Immunizing Agent against Rinderpest.—By controlled experiments and by field tests on a large scale, Nair and Krishnamurti (*Ind. J. Vet. Sci. & Animal Husbandry*, 1941, 11) have confirmed that Rinderpest goat spleen tissue vaccine is potent only for four days at room temperature and that, if used within this period, it confers satisfactory immunity. But the duration of the immunity so conferred is not worked out by the authors yet. They have also confirmed the earlier findings that the reaction set up by the vaccine is often very severe in susceptible cattle and in buffaloes which are more susceptible to rinderpest than the local cattle and they

conclude that this product is unsafe for use in the field in the Madras Presidency.

In Mysore, Rinderpest goat blood virus is used, as it does not involve unnecessary animal sacrifice and as the duration of immunity conferred by it has been worked out by controlled experiments both in Mysore and elsewhere. This vaccine is used alone on indigenous cattle but with varying doses of serum in the case of buffaloes, foreign and cross-bred cattle, pregnant and debilitated animals. S. D. A.

The Geology of Ceylon.—The recent issue of *Spolia Zeylanica* (Vol. 23, Pt. 1)—the Journal of the Colombo Museum, edited by its Director, Mr. P. E. P. Deraniyagala,—contains a number of papers by Mr. D. N. Wadia, Government Mineralogist, dealing with some aspects of the Geology of Ceylon. As is well known, this island was till very recently part of the South Indian Peninsula and therefore shares with it many common features in its geological history such as those relating to the nature of the rocks, geological structure, and plan of architecture. Like Peninsular India Ceylon is mostly composed of extremely ancient crystalline and metamorphic rocks which in the history of the earth constitute the very foundation on which the later fossiliferous sediments were laid down elsewhere. The solitary occurrence of an Upper Gondwana bed near Tabbowa is of special interest in indicating the fact that Ceylon was also part of the great Gondwana continent; and the deformations which the Tabbowa series have undergone enable us to date the most important event in the geological history of Ceylon —the final upwarp of the central *massif*—and fixes it as post-Jurassic. During the enormously long period of time which has elapsed since the ancient Archæan rocks of Ceylon were deposited, they have been subjected to a continuous process of erosion and disintegration resulting in consequences of direct economic benefit to Ceylon; for it has liberated in a concentrated form many valuable economic minerals previously locked up in a vast bulk of the parent barren rock. Thus are to be accounted the famous Ratnapura gem fields, the Pulmoddai and Batticalca ilmenite beaches, the Induruwa monazite sands, etc.

"The Geology of Colombo and its Environs" forms the subject of another paper by Mr. Wadia in which a detailed account of the geology of this part of the country is given, showing that here we have "an epitome of the geology of the whole island of Ceylon". The Archæan rocks of the area—mostly gneisses—described under the name 'Vijaya Series' constitute the main rock formation, overlying which locally we have a few recent and subrecent deposits here and there such as laterite, river alluvia, etc. The deposits of graphite for which Ceylon is so famous, are associated with rocks which have been provisionally designated as equivalent to the Khondalite Series of India.

In another short paper by Mr. Wadia, special attention has been drawn to the ring of waterfalls in Central Ceylon and its bearing on the geological structure and earth movements. In the words of the author, "the existence of precipitous falls disposed in a crescent or ring form suggests that the central highland *massif* of Ceylon, from which the majority of the rivers of the country radiate out fanwise, has received a considerable uplift relatively to the country surrounding it".

The other papers published in the Journal are:—(i) On a Fossil Bamboo Stem and Some Associated Plant Remains from the Gem Deposits of Ratnapura Dt., Ceylon—by Mr. G. S. Puri, of the Botany Department, University of Lucknow, and (ii) On Some Earthworms from Ceylon—by Mr. G. E. Gates, of the Judson College, Rangoon.

Messrs. A. H. Patel and G. Narasimhamurthy write:—"Of the many problems that seriously engage the attention of the Public Health worker in India, the one concerning the place of *Hydrogenated Vegetable Fat in the National Diet* is very important. In the West 'Margarine' is the most common fat food consumed to a great extent and it contains about 10 per cent. of butter fat, besides the hardened vegetable and animal fats. The case is different in India. Ghee is commonly served as such at meals and the untreated vegetable fats are used for culinary purposes. Hardened vegetable fats are an innovation to this country. The sentiment for ghee is so strong that propaganda was carried out that the Vegetable Product is indigestible and that it passes off from the human system as a ballast. (N. N. Godbole, *U. P. Anti-Ghee-Adulteration Conference*, Aligarh, 1941.)

Physiological work relating to the digestibility of this product in India is very meagre and the existing evidence is not found sufficient to condemn the product outright. The notion that ghee supplies vitamins A and D to the body, besides being very digestible is not quite true, because in the way it is processed and marketed, most of the vitamins are liable to get destroyed. Its digestibility compared to the other vegetable fats is not too high to justify the high price paid for it.

May I request your readers to throw more light on the subject for the benefit of all concerned, through the columns of your esteemed Journal."

Cement as a Fire Extinguisher.—Dr. Roy Cross writes in a recent number of *Science* (1942, 95, 275), that "a good deal of caution must be used in the application of pitch to extinguish fire, even though it originates from a magnesium incendiary bomb. It has been the experience of the writer with a great variety of fires in oil, metals and other materials, that there is nothing so satisfactory and so fool-proof as portland cement as it is placed on the market. In many cases in the writer's experience it has been highly successful in extinguishing fires where water, carbon tetrachloride, foam and similar substances have been unsuccessful. The very common material so easily available and so safe to use should be placed at points where there is danger from fires either from incendiary bombs or from normal causes.

"In our own laboratory, we provide such material easily available in kegs and find it far more successful than the usual fire extinguishers. Furthermore, it gives off no injurious gases and is in itself not combustible, as in the case of pitch."

The Differential Resistance of Two Races of Red Scale (Coccidae-Hemiptera-Insecta) to HCN.—Interesting observations on the reactions, to HCN, of the two physiological races of *Aonidiella aurantii* Mask—the one resistant and the other non-resistant to it—were made using examples of two pure stains from California (Hardman, N. F., and Craig, R., *Science*, 1941, 94).

Final instar females of both the resistant and non-resistant races were removed from their hosts before fertilisation; they were confined in suitable glass vials and observed closely under the microscope. Several dilutions of HCN were let into the vials and the spiracles of the scale insects were carefully watched. In structure, the spiracles of the two races are similar, the opening and closure of the organs being simultaneous with every pulsation of the tracheal trunk, which happens about 60 times every minute.

The spiracles of the resistant race remained closed for at least 30 minutes, in the presence of HCN, and the scales themselves survived a lethal concentration for at least that period. In the non-resistant race, the spiracles opened only a minute after HCN reached them, and death followed in a short time when the concentration of HCN was lethal. It is concluded that the relative ability of the two races to keep their spiracles closed when in contact with HCN, explains the difference in the resistance of the two races to the gas.

Control of Damping-off in Seed Beds.—*Pythium de Baryanum* causes damping-off seedlings and particularly causes severe loss in tobacco nurseries. The affected seedlings fall prostrate on the ground, and the collar region of the seedling appears to be pinched off, beginning to rot in due course. Since the infection is soil-borne, powerful fungicides cannot be applied without injurious effects to the roots. The usual nursery practice is to sterilize the surface of the soil by inceneration, which is done by burning dry twigs on the seed bed. 10 per cent. formalin water is also made use of in controlling damping-off with good success. The seed beds after treatment with 10 per cent. formalin water are covered with gunny bags to conserve the effect of formalin. After this treatment the soil is raked up to enable the complete evaporation of formalin which is poisonous to the plant. The whole operation requires 7 to 8 days.

Recently satisfactory control of damping-off in seed beds of lettuce, beet, cabbage and tomato plants has been reported by Doran (*Science*, lxxxlv) by the application of acetic acid in the form of vinegar. Commercial cider vinegar is mixed up with powdered charcoal or moist sand up to 23 per cent. The seed beds dusted with this disinfectant is reported to be free from damping-off to a very great extent. M. J. T.

Hot-Tinning of Mild Steels.—Difficulties are frequently encountered in hot-tinning of certain mild steel articles and components. The Tin Research Institute Publication No. 107, by *W. E. Hoare and H. Plummer* describes how these difficulties may be overcome by removing the contaminated surface by mechanical treatment, deep-etching and anode pickling, or by controlled heat-treatment. "Difficult" tinning quality is ascribed to the formation of adherent lacquer-like films arising from the rolling and drawing lubricants and coolants being partially decomposed in contact with the metal surface by heat and possibly by oxidation and pressure and may be avoided by adequate degreasing prior to the annealing operations.

Calcium Gluconate.—Bulletin No. 29, of the Department of Industries and Commerce, United Provinces, embodies the results of a systematic investigation by *J. B. Lal and K. C. Mukherji* on the manufacture of calcium gluconate by the electrolytic oxidation of glucose. The cost of production on the laboratory scale, works out at Rs. 2-3-0 per lb., and it is expected that this will be much reduced when produced on a larger scale and by using locally made glucose, costing 4 annas a lb.

The Forest Research Institute, Dehra Dun, announces a method (*Indian Forest Leaflet* No. 19) for the preparation of a substitute for 'Carnauba Wax' using indigenous materials (shellac wax, bees' wax, and sal dammar). It is claimed that the substitute has properties very similar to 'Carnauba Wax' which is an essential base for the manufacture of carbon papers, polishes, etc. V. S. G.

Substitute for Metal Drums and Cans.—Substitute containers to take the place of the usual metal drums and cans used for oils, paints, greases, dry goods and other stores have been evolved by the Forest Research Institute.

Owing to the diversion of much tin and sheet metal to army use, manufacturers in India are in sore need of substitute containers. The Institute anticipated this shortage many months back and started experiments on different types of plywood containers. It has now evolved many different designs of plywood drums, containers, canisters, boxes and buckets.

The plywood canisters used for food, dry goods and medical stores are normally lined with a shellac varnish unless required for some purpose which demands a special lining. The drums with iron bands round the top, centre and bottom, are made of strong plywood and are designed for oils, greases and paints. Various inner coatings have been tried and some have already passed the army tests. Ordinary glue is said to be a satisfactory inner coating for oils and greases.

Containers for Parachute Dropping.—Plywood buckets are coated on the inside with hard pitch which renders them waterproof. The round flat containers, specially designed to fit into larger containers made for dropping by parachute are proofed to hold water both for drinking purposes and for machine-guns.

Plywood prototypes of metal boxes can be used for a variety of purposes, such as for tubes of anti-gas grease, hypodermic phials, powders and pills.

Plywood factories in India have already started the manufacture of plywood drums on the lines of the models made at the Forest Research Institute. Plywood drums and containers may be widely adopted not only as a war-time expedient, but also in times of peace. They are easy to make and they should compete favourably with the metal articles.

River Behaviour and its Control.—A new subject—River behaviour, training and control—important for the maintenance of canal headworks and the training of rivers through bridges, figured prominently on the agenda of the annual meeting of the Research Committee of the Central Board of Irrigation in Simla which held its session from July 14 to 18.

Progress has been made in the study of river behaviour at the research stations. The task now undertaken by the Board and its Research Committee is, however, probably the first attempt in India to deal with the problem by a Committee of engineers and research workers.

Two other subjects included for the first time are "Soil Mechanics", in connection with earthen dams and canal banks, and "rainfall run off", dealing with the quantity and rate of discharge of floods from catchments of various sizes.

Among other subjects for discussion are: flow in rivers and canals, hydraulics of boulder rivers, methods of measuring discharges, design of distributory heads, design of canal falls, silting of reservoirs, staunching of canals to prevent loss of water and water-logging of lands.

Quality of Indian Wool.—For the first time in the history of India, a serious effort is made to compile data on the qualities and quantities of wool available in different parts of India [*Handbook on the Quality of Indian Wool* (Manager of Publications, Delhi), 1942. Pp. 49. Price As. 8 or 9d.]. The information collected has been carefully and systematically arranged, and the national importance of the Indian wool industry and the place it occupies in the international trade is clearly brought out. Though the quantity of wool produced in India is only about 2·4 per cent. of the world's output, the actual quantity is 85 million lbs., valued at about 4·2 crores of rupees per annum. The average yield per sheep is the lowest in the world, being about 1·9 lbs. per sheep per annum; the quality is again the poorest according to existing classification, though a fair percentage of it, if properly graded, can be used for the manufacture of better classes of goods and fetch high prices. This is clearly indicated in the tables on pages 36, 37 and 38 of the *Handbook*. Some useful suggestions have been made for the proper grading of Indian wool under "Proposed Classification" which, if followed, would result in securing a higher return to the sheep-rearer.

The subject of sheep-rearing and its economic importance to India has not received the close study it deserves, and it is hoped that a detailed study will be taken up in the near future.

The present study of Indian wool, according to the Central Agricultural Marketing Department, is not by any chance exhaustive. Even in Provinces and States where considerable amount of money has been spent over long periods in improving the stock of sheep, very little systematic data on the qualities of wool produced are available. That there is an urgent need for such a scientific study of wool produced in India, is impressively brought home by the present publication which deserves careful study. The fact that Australia which to-day ranks first among the wool-producing countries of the world had only 20,000 sheep yielding an average of 3 lbs. of coarse wool per sheep per annum, in 1,800, and that by systematic and scientific study, she has improved her stock to 1,015 millions, yielding about 9 lbs. of the finest quality wool per sheep per annum, should be enough to impress on all those concerned with the welfare of India and her large agricultural population the urgent need for applying scientific principles for improving the stocks of Indian sheep and thus place this industry on a secure and prosperous basis. B. K. MURTHY.

"Spotless" Sun for Two Days.—Studies on the intensity of radiation from sun spots relative to the surrounding photosphere have revealed that the character of the radiation from a sun spot is independent of its position on the disc.

The theoretical study on the motion of gases in the sun's atmosphere and the experimental work on Zeeman-effect were continued. The occurrence of highly stripped atoms of iron, nickel, cobalt, etc., in the Corona has been investigated on the basis of the results of the dynamical study of the solar envelope. The conclusions so far reached indicate that these atoms probably originate in the interior of the sun at a depth of about 25,000 km. or more.

In 1941 a further fall in solar activity was indicated by several solar phenomena such as sun spots, prominences and hydrogen absorption markings. Observing conditions were slightly less favourable than in 1940.

Photographs of the sun in ordinary light were obtained on 322 days while spectroheliograms in calcium and hydrogen light were secured on 302 days and 262 days respectively. Under the existing scheme of co-operation among observatories, 63 photographs were obtained from observatories in England and America and 302 calcium disc spectroheliograms were sent from this Observatory to the Solar Physics Observatory, Cambridge.

Laxmi Narayan Institute of Technology, Nagpur.—We have pleasure in announcing that Dr. S. A. Saletore, PH.D., has been appointed as Director of the Institute. Dr. A. Nagaraja Rao, of the Imperial Institute of Sugar Technology, Cawnpore, has been appointed Professor of Applied Physical Chemistry in the same Institute.

The Indian Ceramic Society was revived in March 1941, and the headquarters shifted to the Ceramic Department of the Benares Hindu University. The first number of the *Transac-*

tions was issued in September 1941, and the second number, which is under review, in April 1942. It is hoped to establish a central ceramic library and also a museum of ceramic products and Indian raw materials from which they are made. Contributions of technical books, journals, samples of manufactured goods and raw materials, with details of place of manufacture and occurrence, etc., may kindly be sent to the Hon. Secretary, The Indian Ceramic Society, Department of Ceramics. Benares Hindu University, Benares.

The University of Ceylon.—We have pleasure in announcing that the University of Ceylon was formally inaugurated at Colombo on the 14th July 1942, by Dr. Ivor Jennings, the first Vice-Chancellor of the University.

Ceylon's education was hitherto linked up with the University of London and although the creation of an independent University for Ceylon was under proposal for some years its inauguration so soon would not have been possible but for the extraordinary energy and enthusiasm of Dr. Jennings. His efforts have thus resulted in giving a fillip to the much desired want in the educational system of the island.

The University is residential with faculties for arts and sciences, Oriental languages and medicine for the present. It is learnt that the faculty of law would be added later on.

The University of Delhi.—Academic circles in India will learn with pleasure and satisfaction that the University has been offered a gift of £2,500 by the Rhodes Trustees, towards the endowment of any professorship or lecturership and preferably one of Political Science or English. This is in token of their good will and appreciation of the work now being done by the University.

SEISMOLOGICAL NOTES

During the month of June 1942 five slight and two moderate earthquake shocks were recorded by the Colaba seismographs as against one very great, three moderate and three slight ones recorded during the same month in 1941. Details for June 1942 are given in the following table:—

Date	Intensity of the shock	Time of origin I. S. T.		Epicentral distance from Bombay	Co-ordinates of the epicentre (tentative)	Depth of focus	Remarks
		H.	M.	(Miles)		(Miles)	
4	Slight	12	37	4210	..	100	
6	Slight	20	23	5430	..	..	
10	Slight	15	51	3630	..		
14	Slight	08	40	5070	..	100	
14	Slight	20	00	3640	..	50	
18	Moderate	15	01	4540	..	..	Epicentral region in the neighbourhood of the Lanthe Shoal among the Cardine Islands.
24	Moderate	16	56	8110	Near Lat. 40°S., Long. 180° in the neighbourhood of the North Island, New Zealand.	..	Reported to have been felt at Wellington and other places in North Island, New Zealand. Heavy damage to property was done at Masterton and Palmerston. South Island was only very slightly affected.

MAGNETIC NOTES

June 1942 was less disturbed than the preceding month. There were 20 *quiet* days and 10 days of *slight* disturbance as against 22 days of slight disturbance and 8 of moderate disturbance during June 1941. The day of largest disturbance during June 1942 was the 11th and that of least disturbance the 10th. The character of individual days was as follows:—

Quiet Days	Slightly disturbed days
1, 2, 4–10, 15–18, 20–22, 24–27.	3, 11–14, 19, 23, 28–30.

No magnetic storms occurred during the month of June 1942 while three moderate storms were recorded during the same month last year. The mean character figure for the month was 0·03 as against 1·27 for June 1941.

M. R. RANGASWAMI.

Colaba Observatory,
July 17, 1942.

ANNOUNCEMENT

The Director, Government Test House, Calcutta, has been pleased to notify as follows:— A wide variety of materials, including textile goods, electrical equipment and stores, building and general engineering materials, vacuum brake fittings, metals and alloys, minerals and ores and miscellaneous stores, such as oils, lubricants, paints, varnishes, chemicals, fuels, etc., etc., are tested in the Government Test House, Alipore, Calcutta, to determine their qualities. The charges for tests and analyses are laid down in the "Schedule of Charges" issued by the Government of India. There are two "Schedules of Charges"—one for the Government Departments and the other for private firms and individuals. Copies of these Schedules are obtainable at a nominal price from the Government Book Depots.

The facilities for testing provided in that Office are available to the general public no less than to Government Departments. Fees are charged for all tests carried out and test certificates bearing the Government seal are issued for all samples tested. Such test certificates can be used by firms and individuals for commercial purposes.

The Government of India are alive to the difficulties which nascent and undeveloped Indian industries may experience in getting their products tested at the Government Test House on payment of fees at the scheduled rates, and have given their anxious consideration to the question of affording some measure of relief in the matter of fees in cases which stand in need of such concession. The question of revision of the schedule of fees is under consideration, and pending a final decision on the subject it has been decided, as an experimental measure for a further period of one year, to reduce the testing fees to a certain definite extent in cases where Government are satisfied as to the need for concession.

Firms and individuals intending to take advantage of this concession are requested to apply to the Director, Government Test House, Alipore, Calcutta, substantiating their claim to such concession.

The Government of India have also made provision for the total exemption from payment of fees in specially deserving cases, and firms and individuals, who consider themselves to be in that category, should apply to the Director, Scientific and Industrial Research, University of Delhi, Delhi. On receipt of such applications, the Director, Scientific and Industrial Research, will arrange matters with the Government Test House if he considers that tests free of cost are justified.

We acknowledge with thanks receipt of the following:—

"Journal of the Royal Society of Arts." Vol. 90, Nos. 4607, 4609, 4610 and 4612.

"Journal of Agricultural Research," Vol. 64, Nos. 5-6.

"Agricultural Gazette of New South Wales," Vol. 53, Pt. 4.

"Journal of the Indian Botanical Society," Vol. 21, Nos. 3 and 4.

"Indian Forester," Vol. 68, No. 7.

"Transactions of the Faraday Society," Vol. 38, Pts. 4 and 5.

"Indian Farming," Vol. 3, No. 6.

"Indian Central Jute Committee," Vol. 5, No. 3.

"Review of Applied Mycology," Vol. 21, Pt. 3.

"Nature," Vol 149, Nos. 3773, 3776-80 & 3782.

"American Museum of Natural History," Vol. 49, No. 3.

Books

"Essays in Anthropology," presented to Rai Bahadur Sarat Chandra Roy. Edited by J. P. Mills, B. S. Guha, K. P. Chattopadhayay, D. N. Majumdar and A. Aiyapan. (Maxwell & Co., Lucknow), 1942. Pp. 268. Price Rs. 12 or £1-1.

"Vitamins in Nutrition." (Merck & Co., Rahway, N.J.), 1942. Pp. 32.

"An Introduction to the Chemistry of Cellulose," by J. T. Marsh and F. C. Wood. (Chapman & Hall, London), 1942. Pp. xv + 512. Price 28*sh.*

"Organic Chemistry," by P. B. Sarkar and and P. C. Rakshit. (H. Chatterjee & Co., Ltd., Calcutta), 1942. Pp. vi + 562. Price Rs. 5.

ERRATA

Vol. 11, No. 6, June 1942, page 242

In the legend below Fig. 1, *read* "right" *for* the word "left" within the brackets. In the right half of the page, line 3, the word "right" should be read as "left".

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